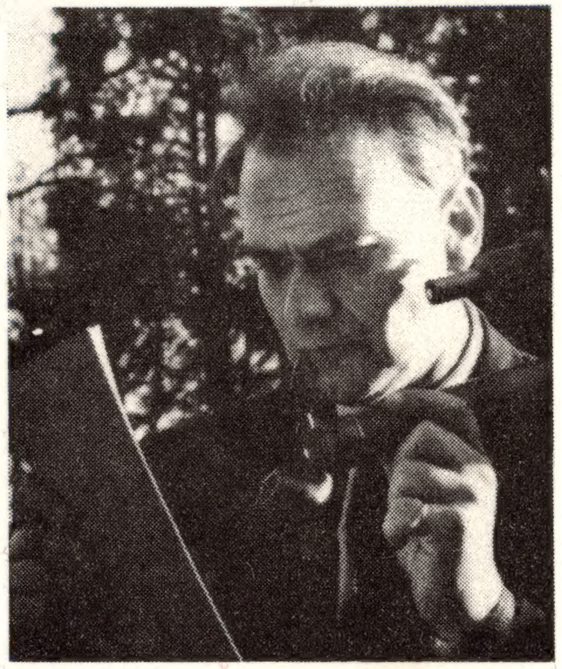
Brooke Bond Picture Cards

THE RACE INTO SPACE

Man's first 50 steps into the universe

5p (1/-)



Patrick Moore, O.B.E., F.R.A.S., F.R.S.A.
The famous British 'TV' astronomer, shows how to project a sun-image on to card to avoid risk to the eyes.

Cover illustrations

MEN TO MARS!

Not science fiction, but the start of the most adventurous voyage ever proposed. An expedition now being planned by American scientists and engineers will involve two space-ships in a 21-month mission to land men on the planet Mars. Its purpose—to survey and look for life on that member of the solar system which most nearly resembles the Earth. On the back cover, the spaceships are under construction in Earth orbit, on the front they are approaching Mars.

WE are living in the Space Age. Science fiction has become science fact, and great advances are being made every year. The Moon has been reached; our rockets have been sent out to the planets Venus and Mars, and within the next decade or two we should be able to receive television pictures from the very boundaries of the Solar System.

Space research has become a part of our everyday lives, and we can watch its progress; by now there can be few people who have not seen starlike points crawling across the sky – the artificial satellites, circling the world and sending back their information. And it is more than likely that some of those who are starting to collect this series of cards will actually go to the Moon – perhaps even beyond. It is a staggering thought, but it is by no means unlikely.

I commend this series of cards; it is factual, comprehensive and well-produced. If you collect the whole series, you will learn much from the pictures and texts. After all, we have entered a new age. Earthly isolationism ended at that moment on July 21, 1969, when Neil Armstrong and Edwin Aldrin stepped out on to the Sea of Tranquillity.

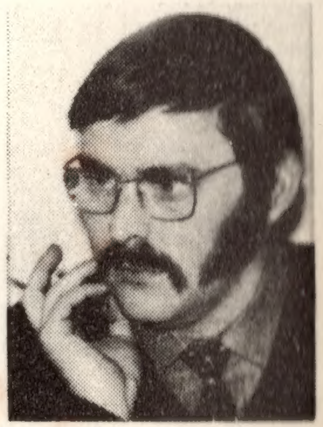
Patrick Moore

Kenneth Gatland
F.R.A.S., F.B.I.S.

Michael Wilson
B.Sc., C.Eng., F.B.I.S., A.F.R.Ae.S.

A TEAM OF SPACE EXPERTS

This series is the work of one of the finest British groups it would be possible to assemble—written by Kenneth Gatland and Michael Wilson; the card illustrations are by David Lawson, and the album illustrations by Roy Cross (cover), Howard Dyke and Clive Harris.



David Lawson

Roy Cross
S.Av.A.

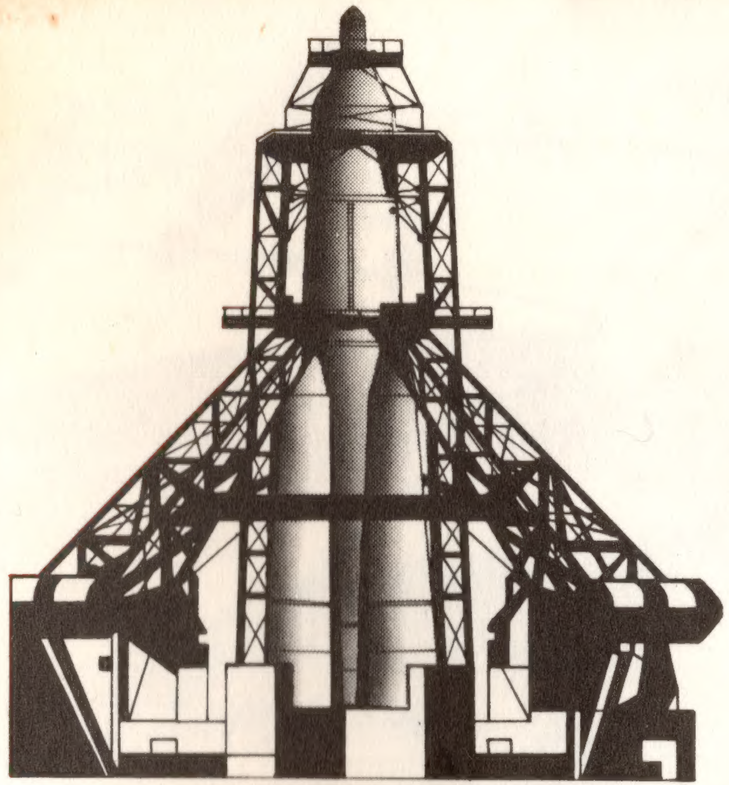
Howard Dyke

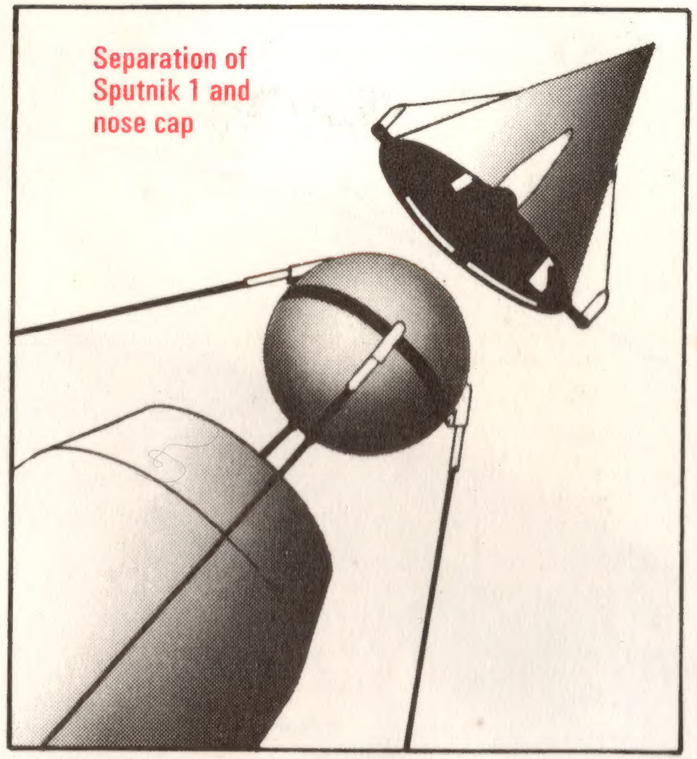
Clive Harris

List of Picture Cards

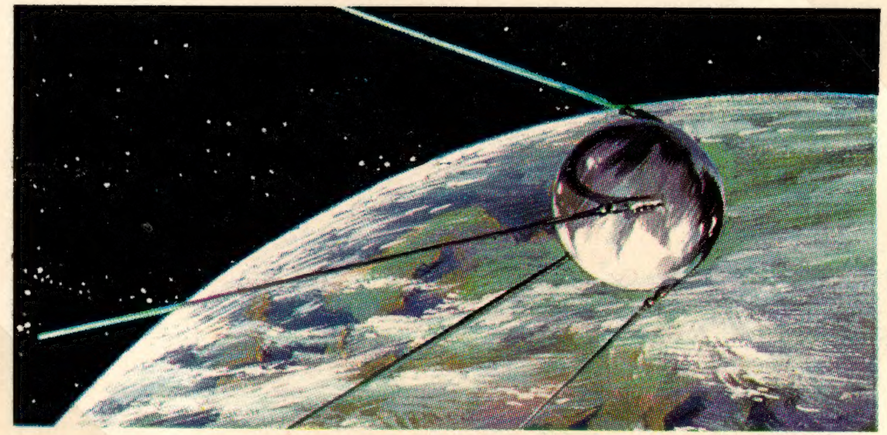
1. SPUTNIK 1
2. EXPLORER 1
3. DISCOVERER
4. TRANSIT
5. ECHO 1
6. VOSTOK
7. VOSTOK ON LAUNCH PAD
8. MERCURY
9. COSMOS
10. ARIEL 1
11. TELSTAR 1
12. ZOND
13. RANGER 3
14. NIMBUS 1
15. VOSKHOD
16. PEGASUS
17. GEMINI 3
18. EARLY BIRD
19. MOLNIYA
20. LUNA
21. METEOR
22. SURVEYOR 3
23. LUNAR ORBITER
24. INTELSAT 3
25. VENERA
26. ATS-3
27. MARINER 4
28. THE GOLDSTONE MARS STATION
29. DEFENCE SATELLITES
30. SOVIET SPACE TRACKING
31. SOYUZ
32. SOYUZ RECOVERY
33. SATURN V AT CAPE KENNEDY
34. APOLLO COMMAND AND SERVICE MODULES
35. APOLLO LUNAR MODULE
36. APOLLO PARACHUTE RECOVERY
37. HEOS
38. ASTERIX-DIADÈME
39. ORBITING ASTRONOMICAL OBSERVATORY
40. SMALL SPACE LAUNCHERS
41. EUROPA 1
42. LUNAR ROVING VEHICLE
43. SKYLAB
44. VIKING
45. 12-MAN SPACE STATION
46. SPACE SHUTTLE
47. THE GRAND TOUR
48. LUNAR SHUTTLE
49. MOON BASE
50. THE MANNED FLIGHT TO MARS

All information contained in this album is based on the latest available at the date of printing.



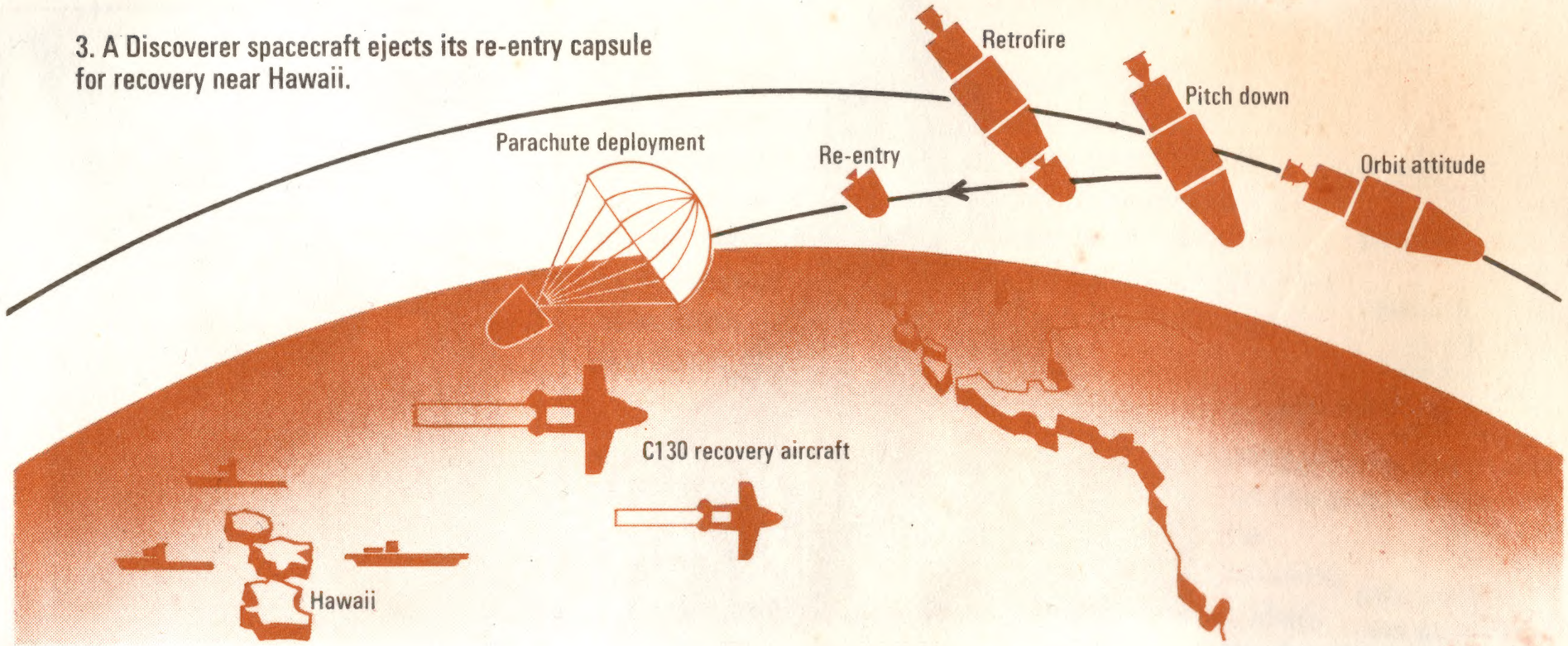


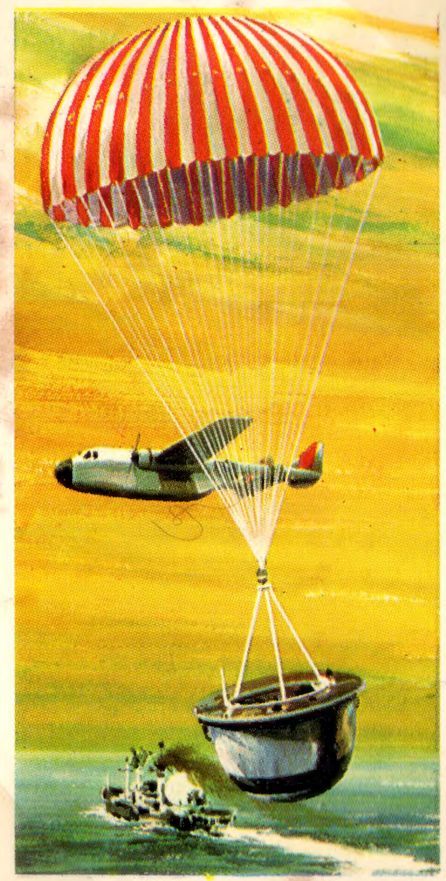
1. The rocket used to launch Sputnik 1 was a rather large vehicle, 91.8ft high and measuring 33.8ft in dia, including the four tapered strap-on boosters which provided added thrust. It was originally designed to deliver an intercontinental ballistic missile to its target, and was developed by the Gas Dynamics Laboratory in Leningrad. In this form it was flown for the first time on Aug. 3, 1957, only two months before the launch of the first Russian satellite. The satellite was covered with a protective shroud which was discarded outside the Earth's atmosphere.



1. Sputnik 1. The very first artificial satellite, Sputnik 1, was launched from the Soviet Union on Oct. 4, 1957 into an orbit varying between 141 and 588 miles above the Earth. Carried by an early intercontinental ballistic missile, the satellite was spherical with a diameter of 22.8in, weighed 184 lb, and had four long aerials. Its carrier rocket, clearly visible as it travelled slowly across the sky, and the 'bleep-bleep' from the satellite's transmitter, were evidence that the space age had arrived. The satellite transmitted for 21 days, and re-entered the Earth's atmosphere on Jan. 4, 1958.

3. A Discoverer spacecraft ejects its re-entry capsule for recovery near Hawaii.





3. Discoverer. The US Air Force gained its 'space wings' with this series of unmanned spacecraft launched into polar orbit from Vandenberg Air Force Base, California. Discoverer 1 was launched on Feb. 28, 1959. The programme had the object of developing a stabilized spacecraft from the orbiting stage of the Thor-Agena launch vehicle, capable of returning a re-entry capsule from orbit. After several failures, Discoverer capsules ejected from the spacecraft over Alaska were caught in mid-air as they parachuted down near Hawaii by the 'trapeze' snares of patrolling C-130 aircraft. The same technique was later used for the USAF's Samos reconnaissance satellites.

2

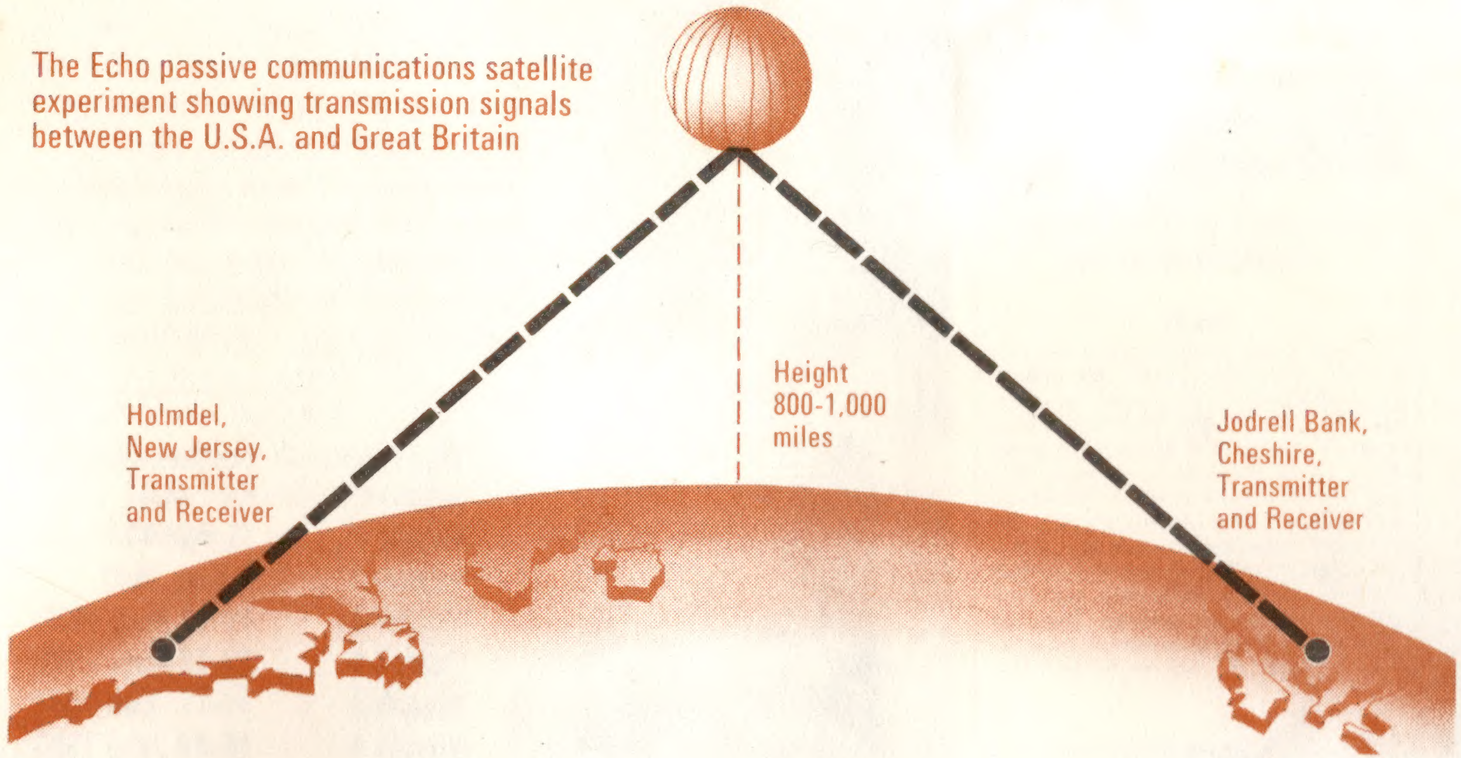
2. Explorer 1. America's first satellite Explorer 1 was launched on Feb. 1, 1958, four months after Russia's first satellite Sputnik 1, and following two disheartening failures of the US Vanguard project. Explorer 1 was a cylinder with a conical nose, 80in. long and 6in. in dia. At 31 lb, it was only one-sixth the weight of Sputnik 1, and was placed in a 224 by 1,584 mile Earth orbit by a US Army Jupiter C rocket. During a four-month active life, this satellite discovered the radiation field surrounding the Earth (named the Van Allen Belt). It re-entered the atmosphere after making 58,376 orbits.

Professor J. A. van Allen, head of the Department of Physics, University of Iowa. Discoverer of radiation belts around Earth.

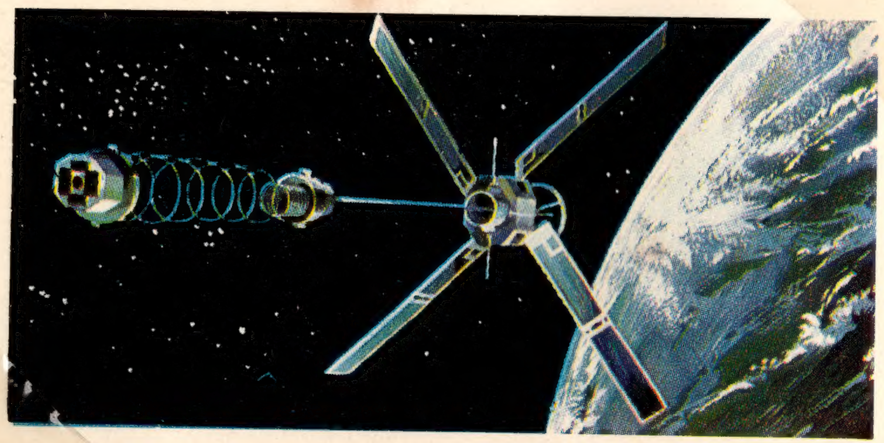
2. America's first satellite, like that of Russia, used a modified rocket originally developed for military purposes. Explorer 1 was placed in orbit by the U.S. Army's Jupiter C. This four-stage rocket was 68.6ft tall, and developed 75,000 lb thrust at lift-off. The satellite re-entered Earth's atmosphere and burned out on Mar. 31, 1970.

The Van Allen Belt is a region where protons and electrons are trapped by the Earth's magnetic field, in the same way rather that iron filings are compelled to adopt a pattern when sprinkled on paper covering a bar magnet.

4. The Transit system comprises several satellites, a network of tracking or receiving stations, a computing centre, a data injection station and navigation receiving equipment on board ship. The satellites are launched into near-polar orbits to provide a service over almost all of the Earth's surface. The basis of the system is the continuous transmission of a very accurate radio frequency. As the satellite rises over the horizon, this transmission is picked up by the ship's navigation receiver. The frequency of the received signal decreases as the satellite moves across the sky, the rate-of-change being a maximum when the satellite reaches its zenith. The frequency continues to decrease until the satellite passes below the horizon. (The process is similar to the whistle of a fast-moving train passing through a station—the *Doppler* effect.) Analysis of the signal gives the exact instant when the satellite reaches its zenith. At the same time, the satellite transmits its own position data from minute to minute. As a result, its actual position in the sky (its orbit) can be determined at its zenith, and so the true position of the ship can be calculated.

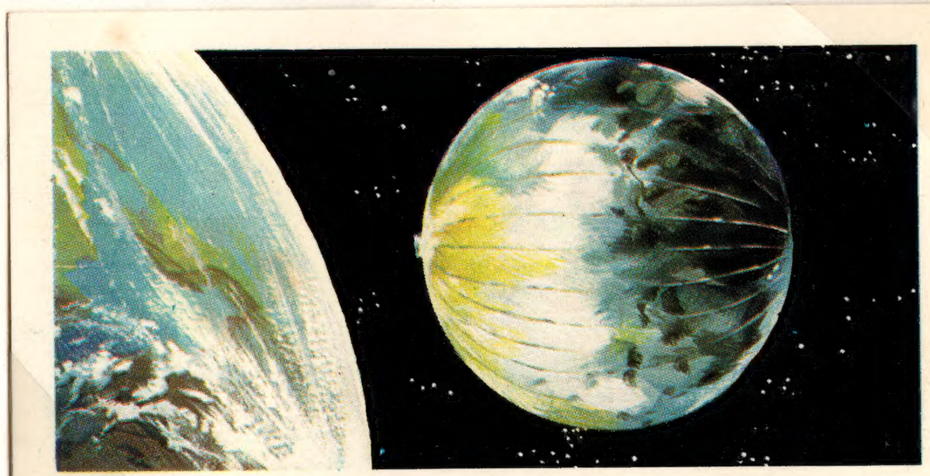


The Echo passive communications satellite experiment showing transmission signals between the U.S.A. and Great Britain

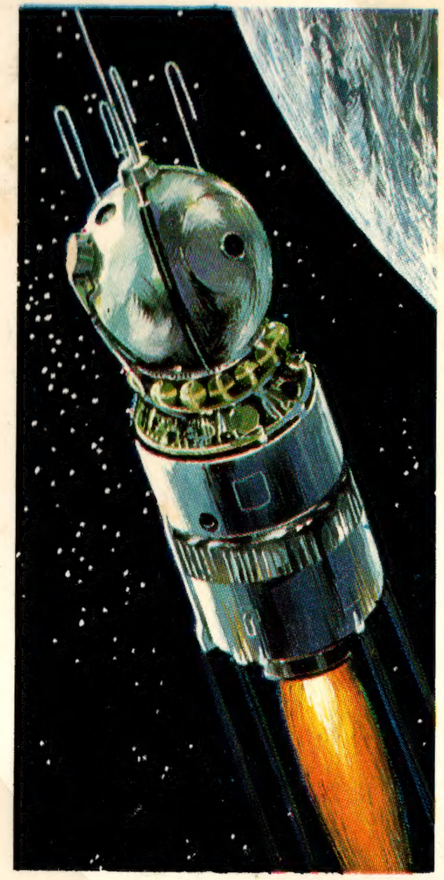


4. Transit. The United States Navy instituted a navigation satellite programme as long ago as 1958 to provide accurate, all-weather positional data for its ships around the world. Ballistic-missile submarines, in particular, need to know their position to a few hundred yards for launching their missiles. The first of a series of Transit satellites was launched from Cape Canaveral on Apr. 13, 1960, into a 232 by 463 mile Earth orbit. The satellites continuously transmit their positions, so that any vessel receiving these signals can locate itself. Some commercial shipping also uses the system.

5. The experimental NASA programme using aluminised Mylar balloons as passive reflectors of radio signals actually involved two satellites. The second of these, Echo 2, was launched on Jan. 25, 1964. After inflation in orbit its diameter was 135ft, rather larger than that of its predecessor, and it was made of thicker material to withstand deformation. A significant event involving Echo 2 was the transmission of signals from Jodrell Bank and their reception in Russia after bouncing off the satellite. It was the first collaborative communication satellite programme involving the two countries.



5. Echo 1 was the first American experimental passive communication satellite. After launch from Cape Canaveral on Aug. 12, 1960, into Earth orbit, it was inflated to form a 100ft diameter balloon. The plastic surface was metal-covered so as to reflect radio waves from a ground-based transmitter to a receiving Earth station thousands of miles away. Many successful link-ups were made across the world before leakage of gas caused it to deform and lose its reflecting power. A spectacular sight, it was seen by many people and it re-entered the Earth's atmosphere on Apr. 24, 1968.



6. Vostok. First man to go into space was Russia's Yuri Gagarin. On Apr. 12, 1961, his 10,418 lb Vostok spacecraft made a single orbit of the Earth inclined at 65° to the Equator and ranging between 109 and 188 miles altitude. The spacecraft comprised a ball-like reentry capsule, containing the cosmonaut on an ejection seat, and a service module with retro-rocket, air supply and gas-jet stabilization. The entire flight from lift-off to touchdown lasted 108 min. Five more cosmonauts later flew in Vostok spacecraft, including the first space woman Valentina Tereshkova. Gagarin was killed in a flying accident on Mar. 27, 1968.

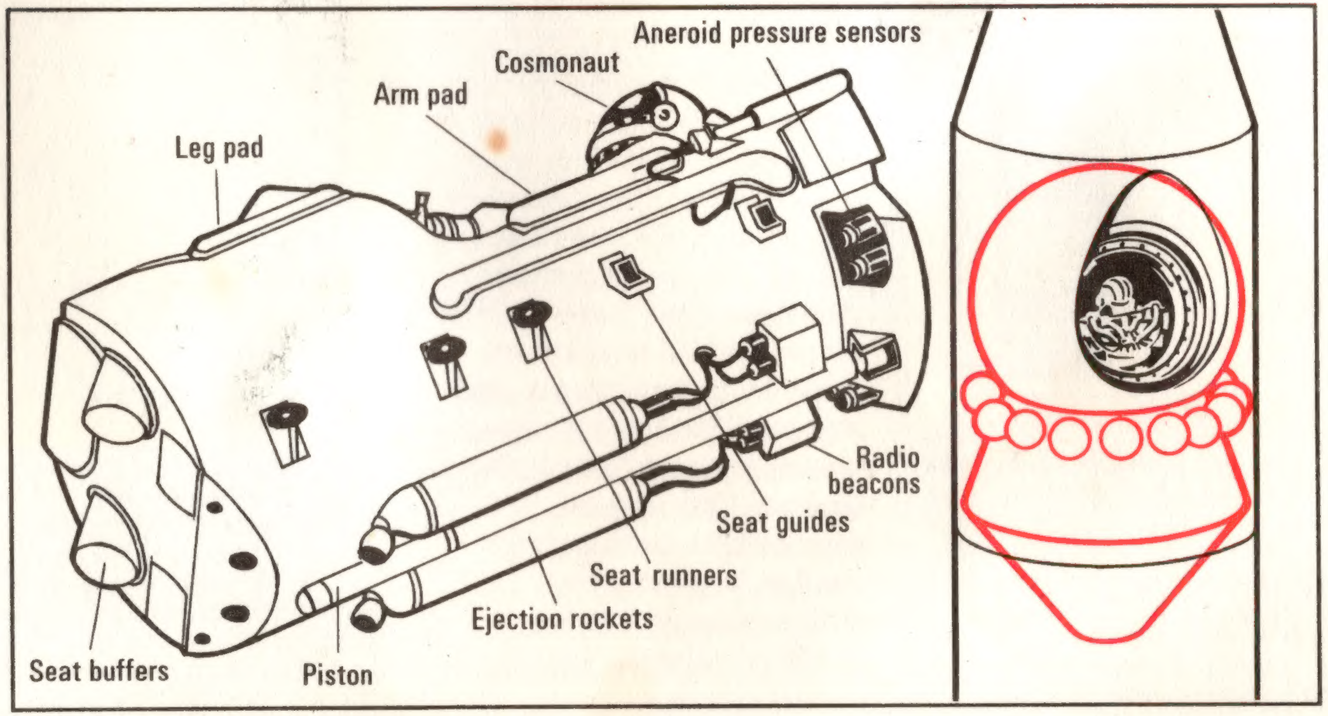
Yuri Gagarin

Valentina Tereshkova

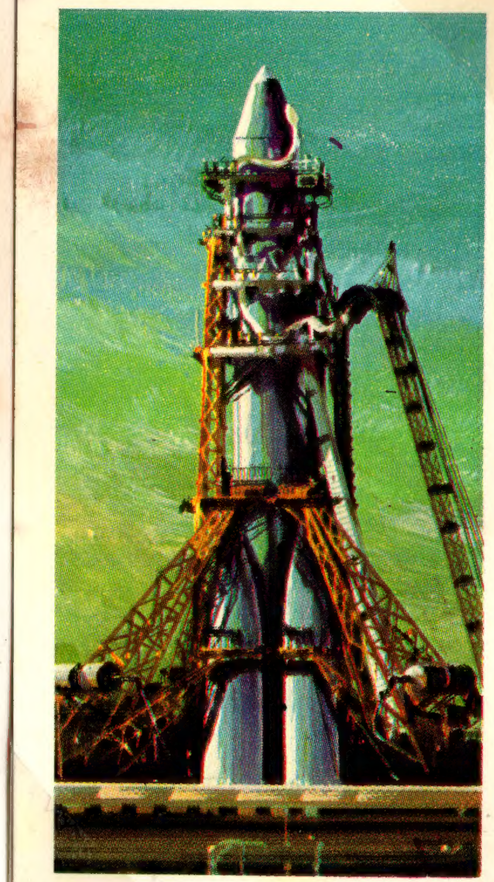
7. Russia's Baikonur cosmodrome is located east of the Northern end of the Aral Sea in Kazakhstan. It was from here that a Soviet heavyweight intercontinental ballistic missile sent Sputnik 1 into orbit in Oct. 1957. This 1½ stage rocket has since been developed to launch much heavier payloads—including the manned spacecraft Vostok, Voskhod and Soyuz—by adding new top stages and increasing take-off thrust.

There were six Vostok missions:

SPACECRAFT	DATE	ORBITS	COSMONAUT
Vostok 1	12 Apr. 1961	1	Gagarin
Vostok 2	6 Aug. 1961	17	Titov
Vostok 3	11-15 Aug. 1962	64	Nikolayev
Vostok 4	12-15 Aug. 1962	48	Popovich
Vostok 5	14-19 June 1963	81	Bykovsky
Vostok 6	16-19 June 1963	48	Tereshkova

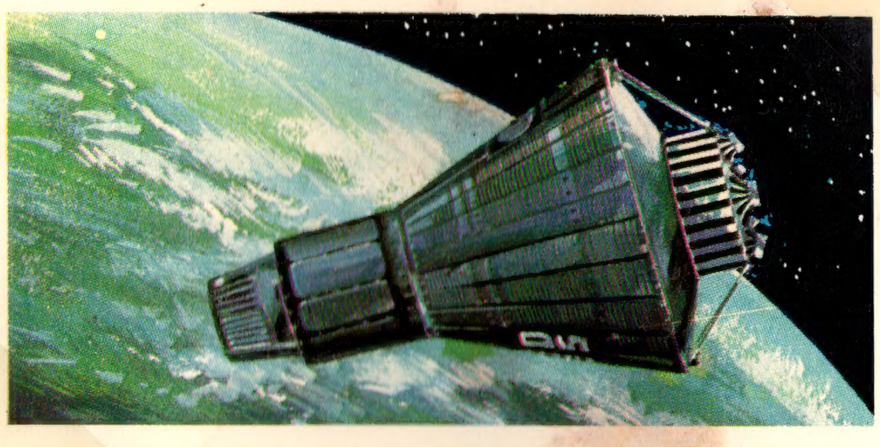


Ejection seat of the Vostok spacecraft.



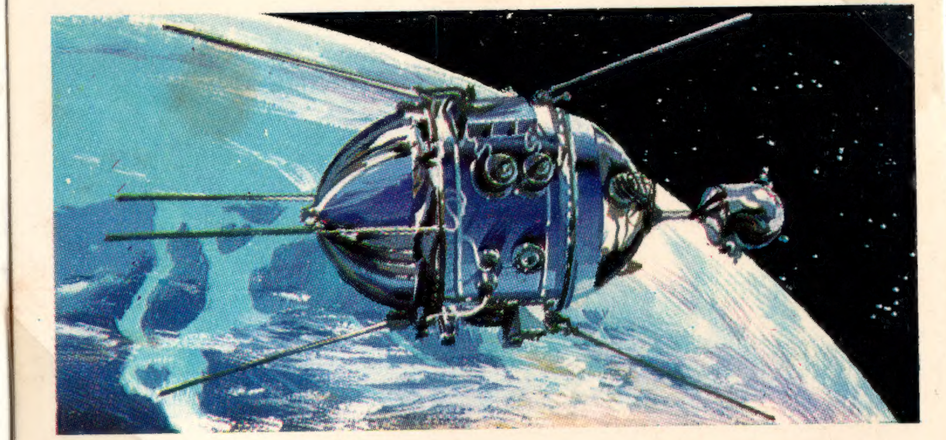
7. Vostok on launch pad. The multistage rocket that lifted Yuri Gagarin into orbit had a two-stage central core plus four tapered strap-on boosters. Total thrust of all stages was 1,323,000 lb. Assembled horizontally on a transporter-erector, the combined rocket and spacecraft was taken out of the preparation building to the launch pad on a railed track. At the pad, the empty launcher was lifted into a vertical position and cradled by four hinged 'steady' arms. Servicing platforms also hinged into position around the rocket ready for final checkout and fuelling with liquid oxygen and kerosene.

How the seat could be ejected from the launch vehicle at an upward angle after the explosive separation of a circular hatch.



8. Mercury. First American to orbit the Earth was Colonel John Glenn. Launched from Cape Canaveral by Mercury-Atlas MA-6 on Feb. 20, 1962, his Mercury capsule Friendship 7 completed three orbits in 4 hr 55 min. Two earlier manned Mercury flights—sub-orbital—were launched by Redstone rockets. Alan Shepard made a 15 min 22 sec ballistic lob over the Atlantic on May 5, 1961 and Virgil Grissom (later killed in the Apollo launch pad fire) made a similar flight on July 21, 1961. Both were successful but Grissom's capsule sank after the hatch blew out and it filled with water.

9. Few details are available of the large Cosmos satellites which eject capsules for recovery over the Soviet Union. The frequency with which launchings occur into low orbits suggest their main task is observation of the Western World and Communist China. Hundreds of Cosmos satellites, including recoverable and non-recoverable types, have been launched—many having standardised features to achieve 'production line' economy in manufacture.



9. Cosmos. Large quantities of these satellites have been launched. Some are used for scientific research into the space environment, and others to test new spacecraft systems with civil and military applications. Cosmos 1, a non-recoverable scientific satellite, was launched on Mar. 16, 1962 from Kapustin Yar. Many of the larger spacecraft launched from Baikonur and Plesetsk apparently have reconnaissance duties; they eject capsules for recovery over Soviet territory usually within 8 to 12 days. Illustrated is one of the smaller non-recoverable scientific satellites.

Virgil Grissom

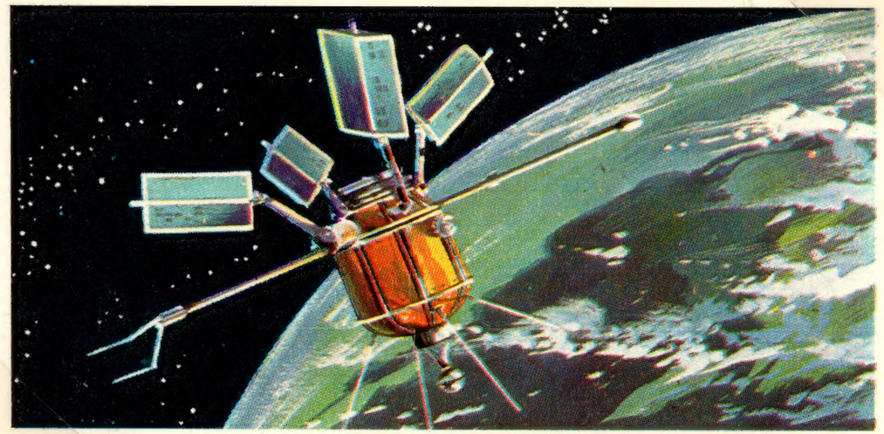
John Glenn

Alan Shepard

Six missions were also flown by Mercury astronauts:

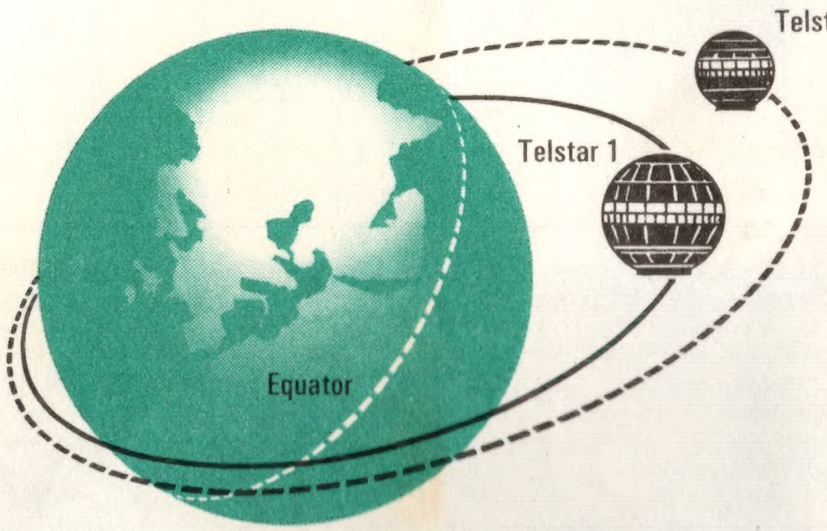
SPACECRAFT	DATE	ORBITS	ASTRONAUT
Freedom 7	5 May 1961	Sub-orbital	Shepard
Liberty Bell 7	21 July 1961	Sub-orbital	Grissom
Friendship 7	20 Feb. 1962	3	Glenn
Aurora 7	24 May 1962	3	Carpenter
Sigma 7	3 Oct. 1962	6	Schirra
Faith 7	15-16 May 1963	22	Cooper

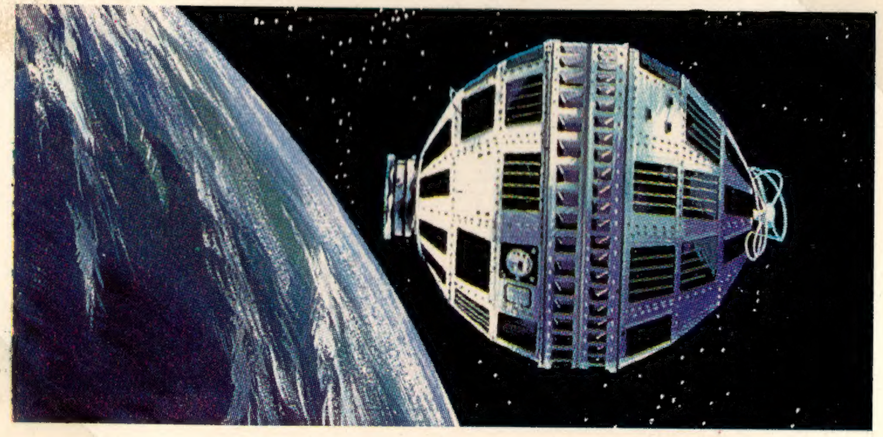
10. Britain's Ariel satellites are designed purely for scientific research, and stem from a joint Anglo-American programme originated in Mar. 1959. In fact, Ariel I was the very first international collaborative space programme. Ariels 1 and 2 were built in America, but contained British scientific experiments. Ariel 3 was the first satellite to be built entirely in Britain, under the direction of the Ministry of Aviation (now the Ministry of Technology). Ariels 2 and 3 were launched on Mar. 27, 1964, and May 5, 1967, respectively. Development of a fourth satellite is under way.



10. Ariel 1. Britain's Ariel 1, built in America, was fitted with British scientific experiments, and was launched into a 754 by 242 mile orbit by an American Delta rocket from Cape Canaveral on Apr. 26, 1962. The 132 lb satellite carried seven experiments, from three British universities, designed to provide purely scientific information about the ionosphere, the complicated region of particle and magnetic fields which surrounds the Earth at an altitude of about 100 miles. Ariel 1 continued to transmit data until Nov. 1964, when it fell silent, but it was still in orbit at the beginning of 1970.

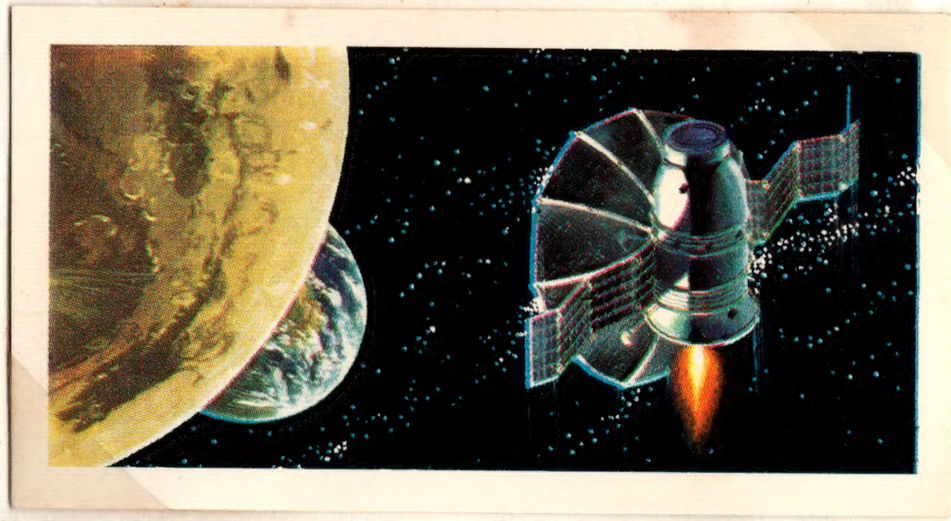
11. The experimental Telstar programme involved two satellites, the second of which was launched on May 7, 1963. Following the early unserviceability of Telstar 1, certain steps were taken to increase the life of Telstar 2. Externally similar to its predecessor, it carried a number of internal changes to improve reliability, while a higher orbit (604 by 6,713 miles, against the 593 by 3,503 miles of the earlier satellite) was adopted to lessen the exposure to damaging radiation. Telstar 2 continued to relay TV and radio transmissions until May 1965.



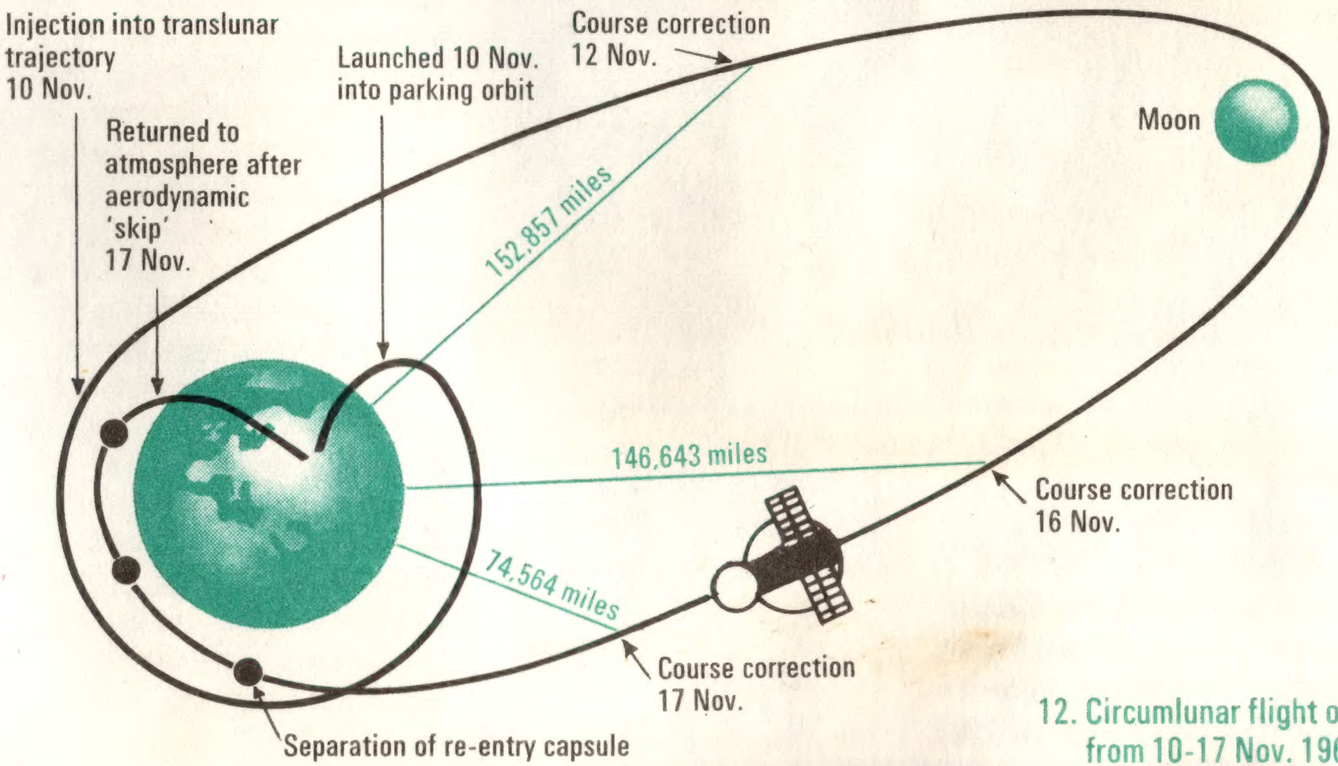


11. Telstar I pioneered many of the techniques now universally employed in commercial relay satellites. The 34.5in. dia., 170 lb Telstar 1 was launched from Cape Canaveral on July 10, 1962. Thirteen days later the first, historic, direct, full-scale television exchange, lasting 20 min, took place between Europe and America. In a second television link-up there were no less than 50 cameras taking part in nine European countries, and the programme was relayed to North America. Telstar 1 was used for extensive tests before becoming unserviceable during Feb. 1963.

12. No photographs or illustrations of Zond craft have been released by the U.S.S.R. The card illustration is based on an impression of the Zond circumlunar spacecraft prepared by French journalist Jacques Tiziou and artist L. Murtin.

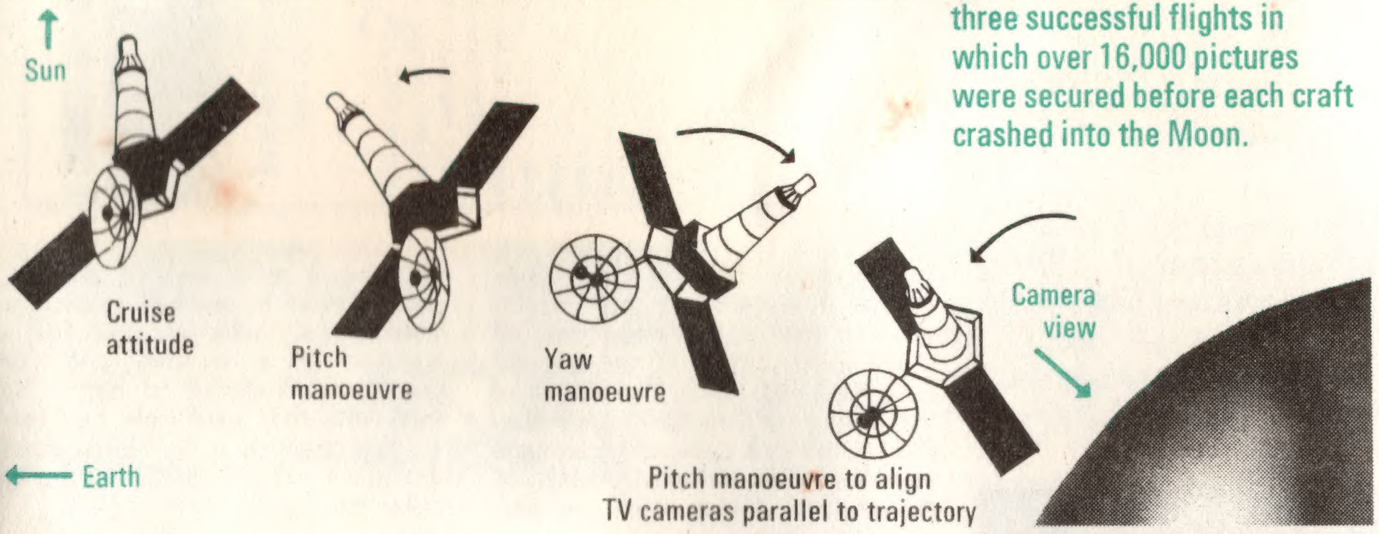


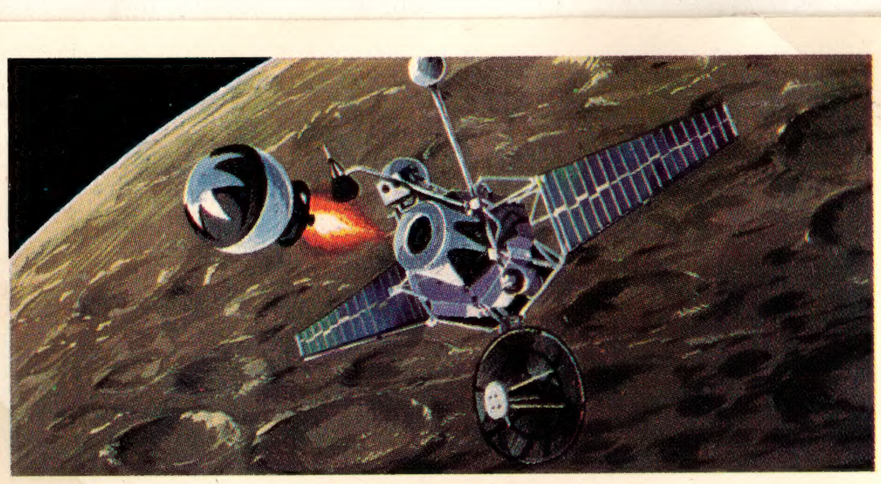
12. Zond. Several unmanned Russian Zond spacecraft have been launched to the Moon and planets. Zond 3, sent into orbit round the Sun on July 18, 1965, took pictures of the Moon's far side as it passed. Between Sept. 15-21, 1968, Zond 5 made the first unmanned flight around the Moon and back to Earth, landing its capsule by parachute in the Indian Ocean. Its 'passengers' included turtles, wine flies, mealworms, lysogenic bacteria and various plants and seeds. Zond 6 and 7 in Nov. 1968 and Aug. 1969 made similar circumlunar flights but were recovered in the Soviet Union.



12. Circumlunar flight of Zond 6 from 10-17 Nov. 1968.

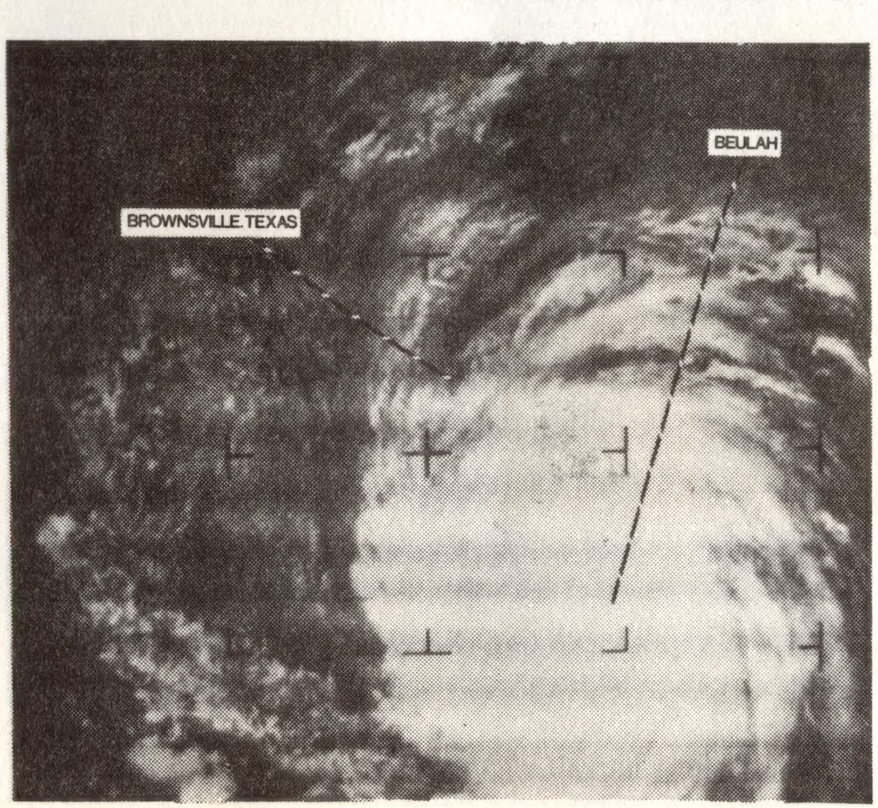
13. The Ranger Programme, initiated by NASA in 1960, was America's first project aimed at the investigation of the Moon. Nine spacecraft were built. After two unsuccessful experiments with Ranger spacecraft in Earth orbit—the first was launched on Aug. 23, 1961—the next three Rangers failed to accomplish their tasks of placing instrument capsules on the Moon, and, during 1963, the programme was re-designed around a new object: photography of the Moon, in support of Apollo. Ranger 6 (launched Jan. 30, 1964) again failed, but was followed by three successful flights in which over 16,000 pictures were secured before each craft crashed into the Moon.

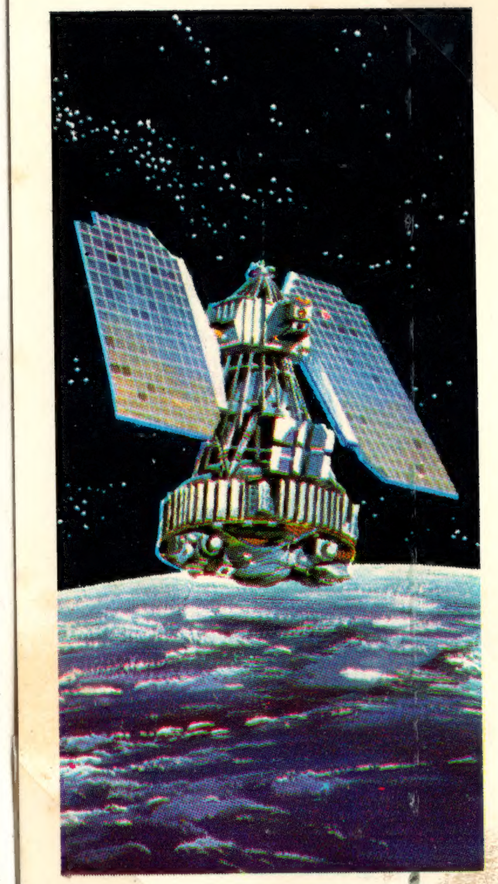




13. Ranger 3. Ranger was the name of a series of nine basically similar American spacecraft designed to hard-land scientific instrument capsules on the Moon and photograph its surface. Ranger 3, the first US attempt to photograph the Moon from close range, was launched by Atlas-Agena rocket from Cape Canaveral on Jan. 26, 1962. The 727 lb spacecraft with its 24in. dia., 92 lb capsule, was given too high a velocity and passed by the Moon at 22,862 miles instead of 5,000 miles. The capsule was not released and efforts to photograph the Moon failed.

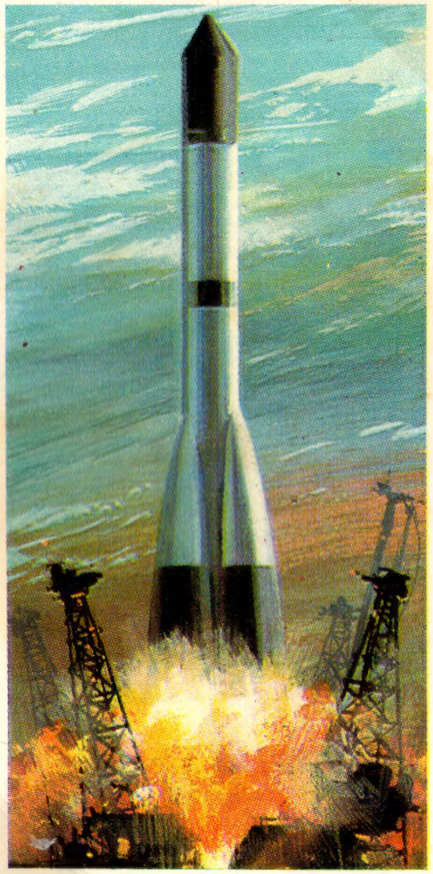
14. No less than five families of American satellites have been developed to provide weather-prediction services or to study meteorological processes. The first was the TIROS (Television and Infra-red Observation Satellites) series. These were followed by the ESSA (Environmental Science Services Administration) satellites, the first operational system. Both types are in low orbits. Research at synchronous height is the purpose of some of the ATS types, while the Nimbus series provide a platform for attitude-stabilised research. The first of a new stabilised operational series, ITOS-1 (Improved Tiros Operational Satellite) was launched in Jan. 1970.





14. Nimbus 1, launched from Cape Kennedy on Aug. 28, 1964, was the first of America's second-generation experimental weather satellites, superseding the earlier series of Tiros satellites. Unlike the latter, which were spin-stabilised, Nimbus 1 was stabilised so that its experiments remained pointed at the Earth. It was placed in an elliptical, 263 by 579 mile path around the Earth instead of the circular 575 mile orbit planned. 27,000 pictures of excellent quality, covering the entire Earth, were synthesised at a large number of picture receiving stations during 26 days of active life before power failure terminated its career.

Photograph taken by the Nimbus 2 satellite in Sept. 1967 tracking the path of Hurricane 'Beulah'.

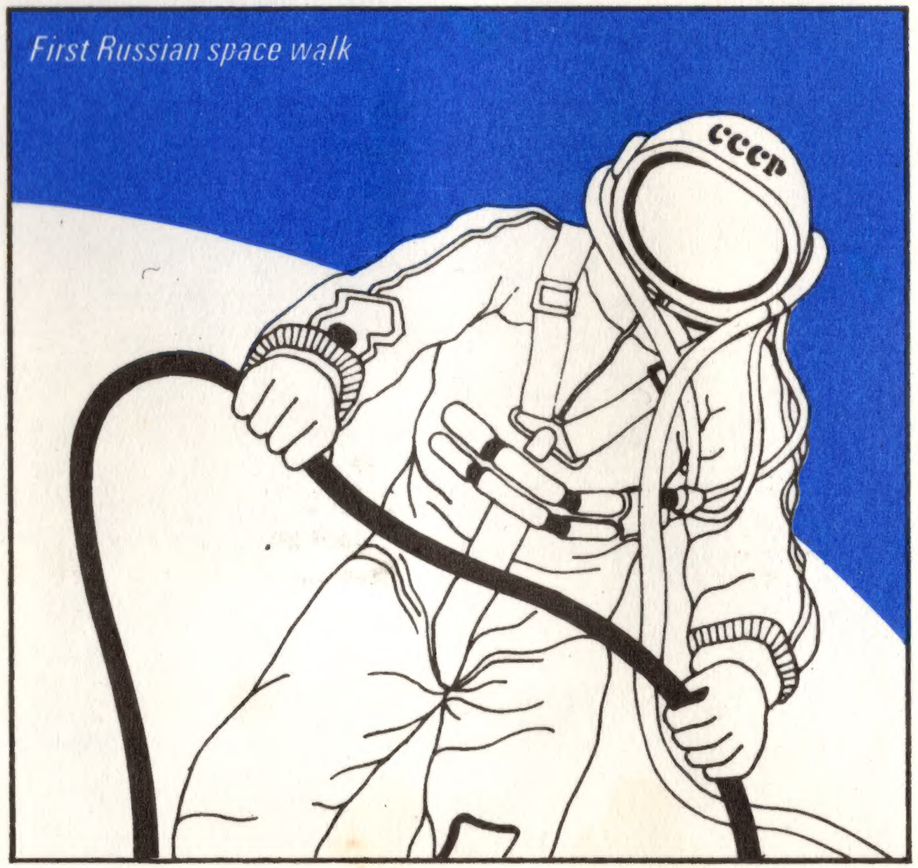


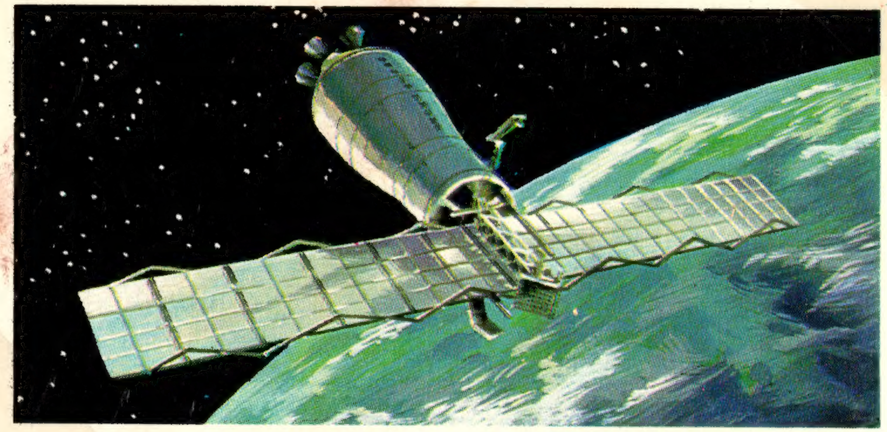
15. Voskhod. This manned spacecraft filled the gap between Vostok and Soyuz. With cosmonaut Vladimir Komarov in Voskhod 1 on Oct. 12, 1964 were a doctor Boris Yegorov and a scientist Konstantin Feoktistov. They completed 16 orbits in a flight lasting 24 hr 17 min 3 sec. Spacesuits were not worn and the capsule's parachute landing was cushioned by retro-rockets ignited just before ground contact. Voskhod 2, launched on Mar. 18, 1965, carried Pavel Belyaev and Alexei Leonov. Both wore spacesuits allowing Leonov to make history's first 'space walk' of about 10 minutes' duration from an extensible airlock. Their flight lasted 26 hr 02 min 17 sec. Cosmonaut Belyaev, aged 44, died in Moscow on Jan. 10, 1970, following an operation for a stomach ulcer, from peritonitis.

Alexei Leonov

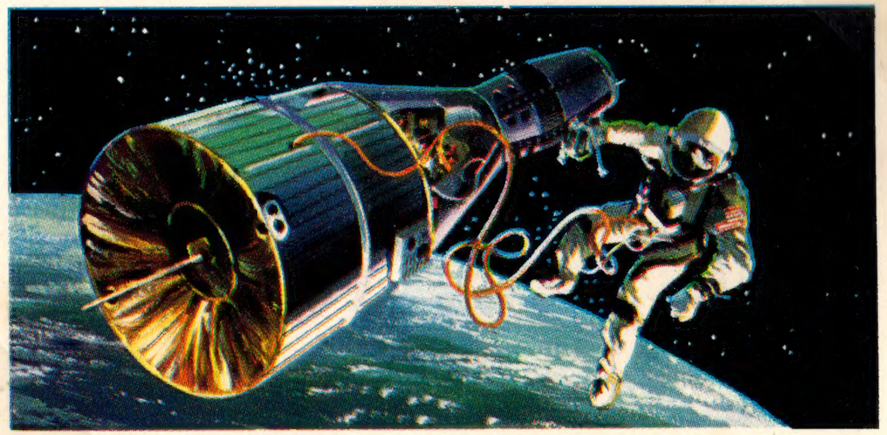
Pavel Belyaev

15. During his pioneer 'space walk', Leonov received his oxygen from cylinders strapped to his back. The lifeline included cables for communications with co-pilot Belyaev (and ground command) and for relaying data from bio-medical sensors attached to his body. Leonov spent 23 min 41 sec outside the Voskhod 2 cabin, more than half that time in the airlock.

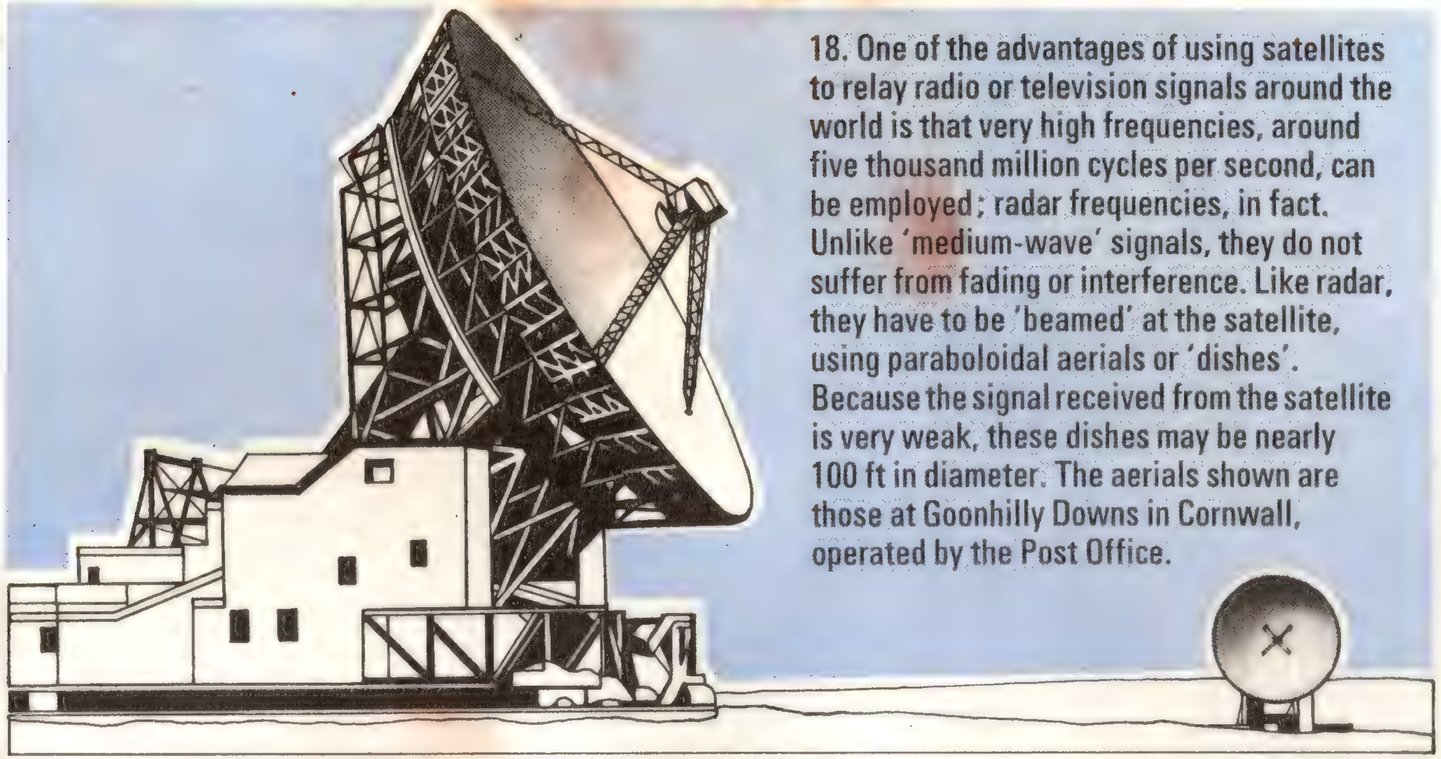




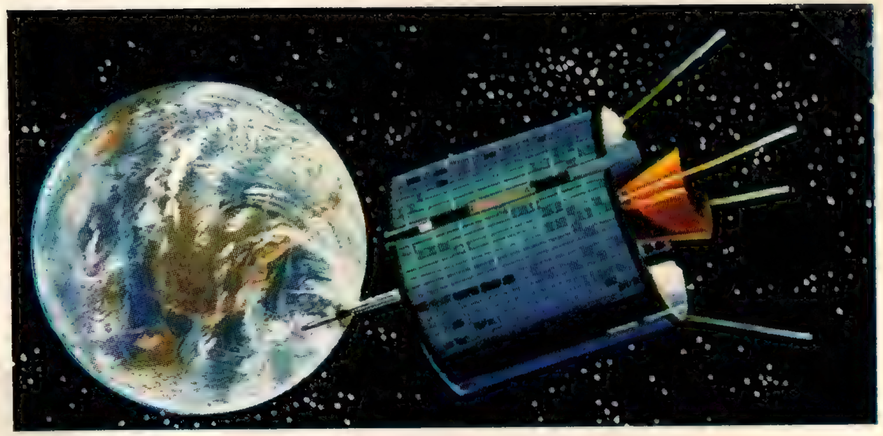
16. Pegasus. Three of these huge satellites were sent into Earth-orbit in 1965 to test mock-ups of the Apollo command and service modules and study the size and frequency of micro-meteoroids. Each craft had concertina 'wings' spanning 100 ft—a sandwich of aluminium, Mylar and copper, carrying a mild electric current; when struck by a small particle a short-circuit was created for a fraction of a second, and the results telemetered to Earth. By mid-1966 the satellites had recorded more than 1,100 impacts, but none sufficiently damaging to deter the Apollo Moon flights.



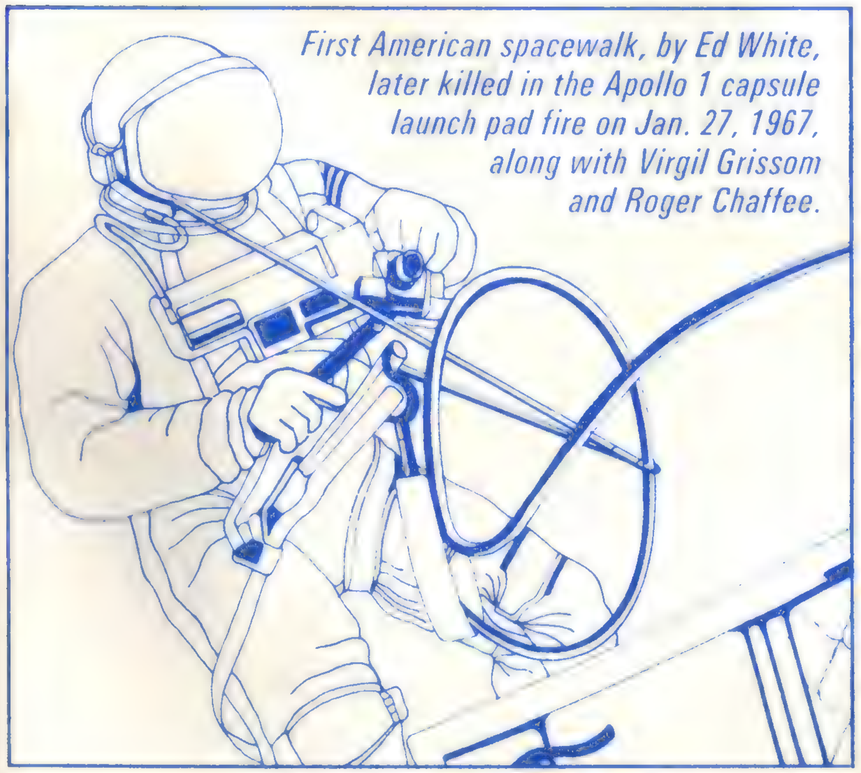
17. Gemini 3 was the first of ten highly successful operational flights with the two-man American spacecraft. Flown by Virgil Grissom and John Young, it was launched by a Titan 2 rocket from Cape Kennedy on Mar. 23, 1965. It was placed in an initial orbit inclined at 33° to the Equator and varying in height between 100 and 139 miles. After a 3-orbit flight lasting 4hr. 53min., the spacecraft was recovered successfully in the Atlantic. The illustration depicts Gemini 4, with crewmember Ed White making the first American space walk, which was of 21 minutes duration.



18. One of the advantages of using satellites to relay radio or television signals around the world is that very high frequencies, around five thousand million cycles per second, can be employed; radar frequencies, in fact. Unlike 'medium-wave' signals, they do not suffer from fading or interference. Like radar, they have to be 'beamed' at the satellite, using paraboloidal aerials or 'dishes'. Because the signal received from the satellite is very weak, these dishes may be nearly 100 ft in diameter. The aerials shown are those at Goonhilly Downs in Cornwall, operated by the Post Office.



18 Early Bird. Following successful trials, the world's first commercial communications satellite was launched from Cape Kennedy on Apr. 6, 1965. On June 28 of that year, from its position 22,300 miles above the Atlantic, it began relaying telephone calls and live television programmes between Europe and North America. Noteworthy events included coverage of the two-man Gemini spacecraft launches and recoveries, the interchange of stock-exchange prices, and information leading to the arrest of a Canadian criminal. The satellite was switched out of service in 1969.

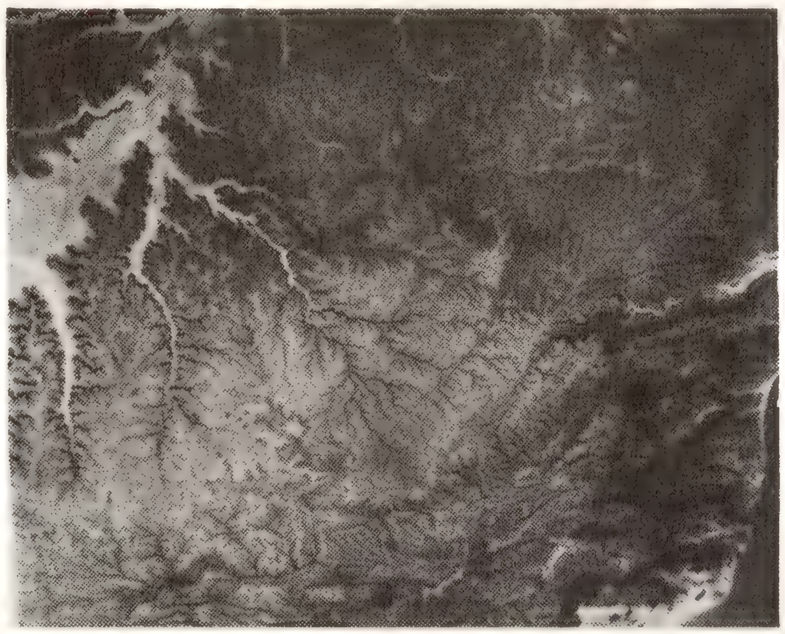


First American spacewalk, by Ed White, later killed in the Apollo 1 capsule launch pad fire on Jan. 27, 1967, along with Virgil Grissom and Roger Chaffee.

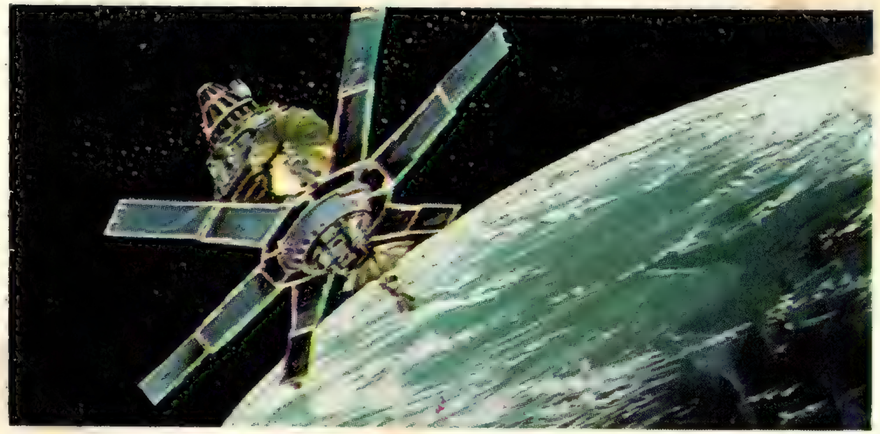
Ed White

Roger Chaffee

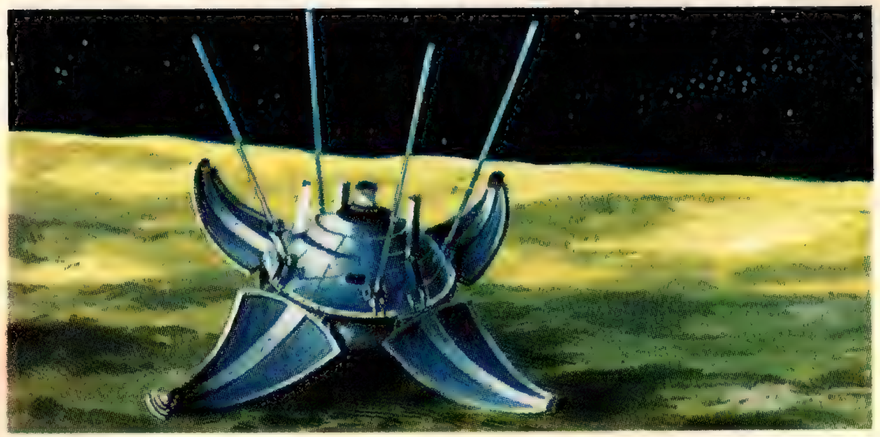
17. Gemini followed Mercury as America's second-generation manned spaceflight programme and was used to verify many of the techniques to be adopted for Apollo. The planned schedule of ten manned launches was carried through with great success, terminating with the flight of Gemini 12 on Nov. 11, 1966. Gemini gave rise to a number of notable American 'firsts': docking between manned and unmanned spacecraft, rendezvous between two manned spacecraft, space-walking and many others. The orbits of these spacecraft could be changed by the use of control rockets. The astronauts returned a host of fine photographs of Earth.



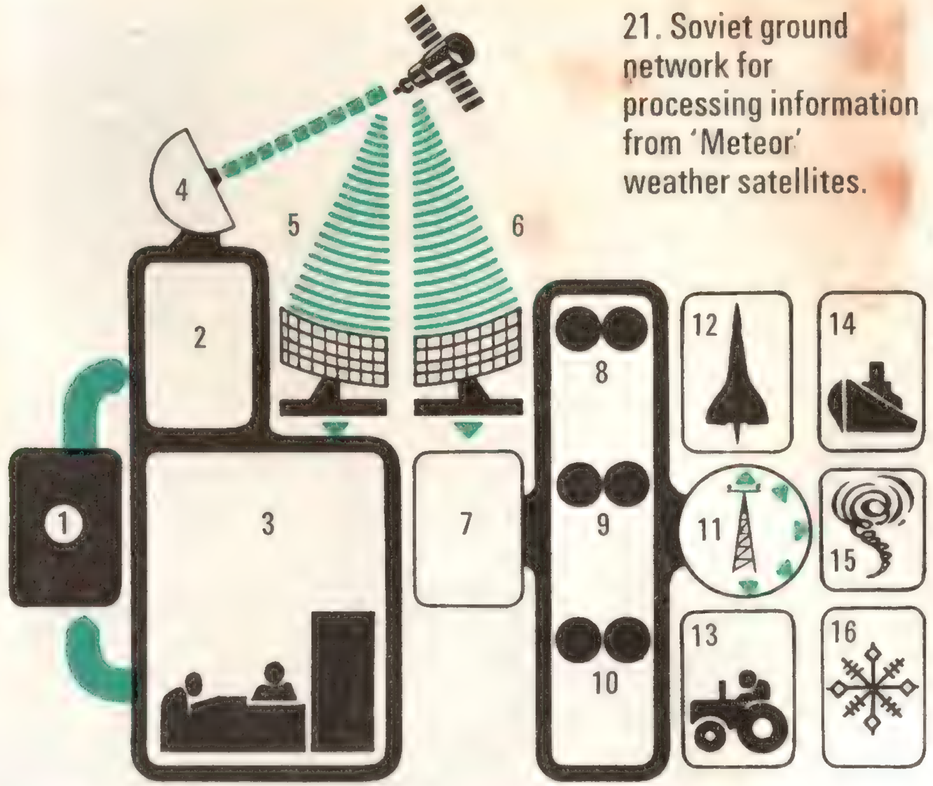
The face of our planet: The once-mysterious Arabian Desert (near Aden) bares its secrets to the camera of astronaut James A. Lovell in a 1965 Gemini flight.



19. Molniya. These Soviet satellites relay television, telegraph and multi-channel radio services across the USSR. Orbits are highly elliptical extending to nearly 25,000 miles in the northern hemisphere and dipping below 310 miles in the southern hemisphere. A network of 'Orbita' ground stations allows people in Siberia, the Far East and the Far North, to receive Moscow television. A particularly interesting function of Molniya is the transmission of weather charts and newspaper facsimiles. France has participated in Molniya experiments – Moscow to Paris.



20. Luna. Russia's triumphant Moon probes began in 1959 when her unmanned spacecraft passed, hit and looped behind the Moon. Luna 3, launched on Oct. 4, 1959, took the first photographs of the Moon's hidden side, sending film-images to Earth by television. Luna 9—the first spacecraft to soft-land on Feb. 3, 1966—sent TV pictures and cosmic ray data from within a shallow crater in the Ocean of Storms. Luna 15, a manoeuvrable mooncraft, was in lunar orbit at the time that America's Apollo astronauts were attempting man's first lunar landing in July 1969.

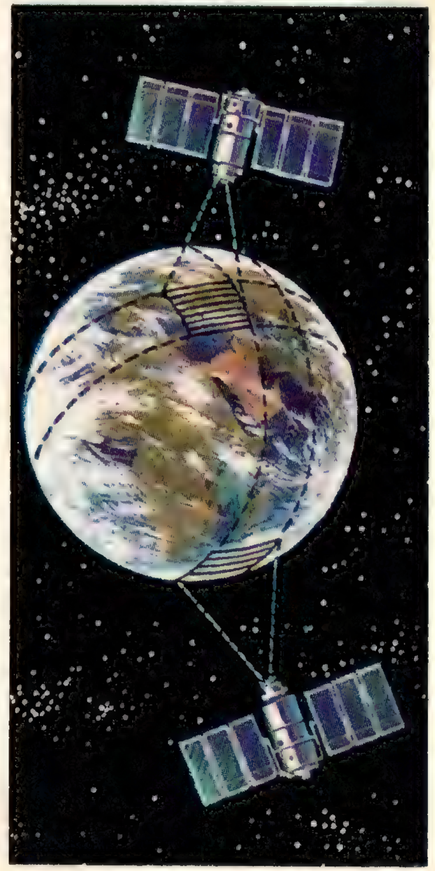


21. Soviet ground network for processing information from 'Meteor' weather satellites.

The 'Meteor' System Scheme

1. Command centre.
2. Equipment for command radio link.
3. Automatic processing of satellite performance data.
4. Command link antenna.
5. Satellite performance data.
6. Radio link for meteorological information.
7. Meteorological information receiving station.
8. Processing of TV data.
9. Processing of solar heat data.
10. Processing of infra-red data.
11. Hydrometeorological centre of U.S.S.R. broadcasting forecasts.
12. For aircraft.
13. For agriculture.
14. For shipping.
15. Advance warning of dangerous weather conditions.
16. Assessing snow cover.

20. Luna 13, which also soft-landed in the Ocean of Storms on Dec. 24, 1966, photographed the landing area and probed the surface with a mechanical soil meter and a radiation density meter. An earlier satellite, Luna 10, became the Moon's first artificial satellite, Apr. 3, 1966.



21. Meteor. These Soviet satellites photograph Earth's changing cloud cover by day and night, observe the distribution of snow and ice, and give advance warning of hurricanes and typhoons. Experiments began within the Cosmos programme, including temperature measurements of the Earth's surface and cloud tops. Meteor 1 was launched on Mar. 26, 1969 into a 393-427 mile orbit inclined at 81.2° to the Equator. Pictures can be sent direct to ground stations or stored in the satellite for transmission later. Moscow, Leningrad and other centres broadcast periodic warnings of abrupt weather changes, combining data from meteorological radar and satellites.

Surveyor's approach and landing on the Moon

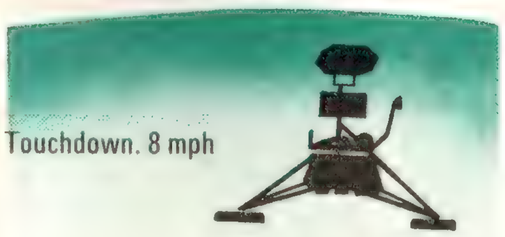
Cruise attitude (Solar panels face Sun)

Rotation to align retro-rocket with flight path 30 min. to touchdown

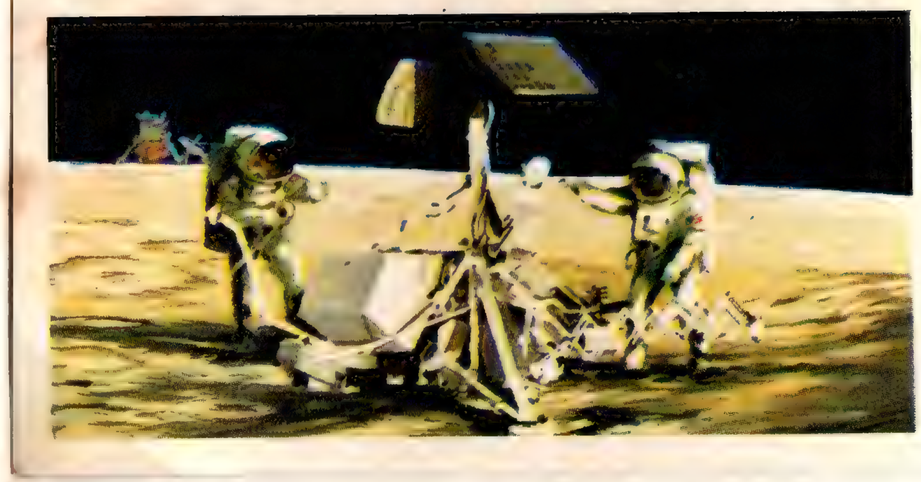
Height-finding radar jettisoned after commanding main retro start. Craft stabilised by verniers. Height 52 miles. Speed 5,900 mph

Main retro burn-out and jettison. Vernier retros begin. Height 37,000 ft, speed 400 mph

Vernier retros shut off. 14 ft. 3.5 mph

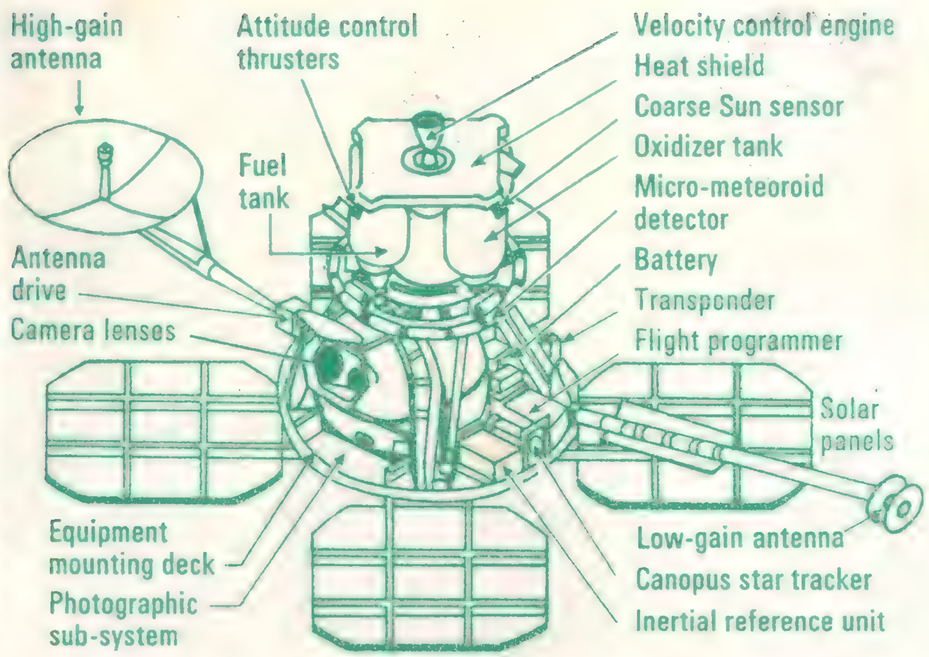


Touchdown. 8 mph

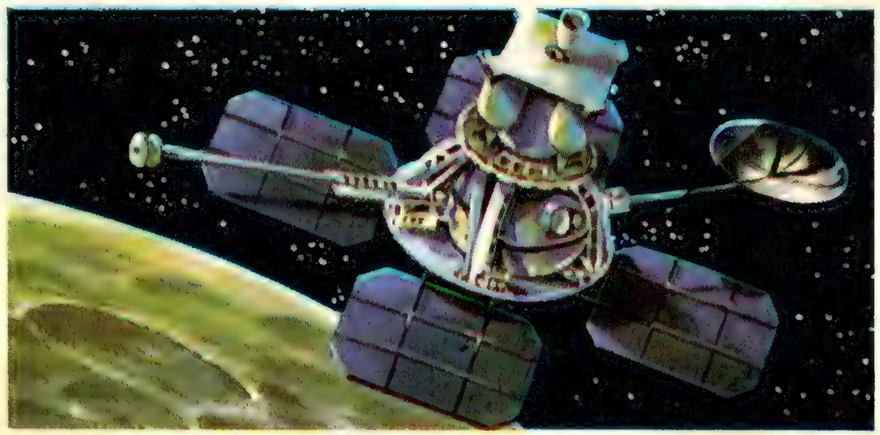


22. Surveyor 3. Launched from Cape Kennedy on Apr. 17, 1967, Surveyor 3 made a successful soft-landing on the Moon after a 65hr flight. Its task was to develop soft-landing techniques and to provide scientific and engineering information in support of the Apollo manned Moon-landings. Surveyor 3 was fitted with a mechanical sampler and was commanded to dig a number of trenches in the soil to assess its texture, while a TV camera on the spacecraft viewed the operation. On Nov. 20, 1969, Surveyor 3 was visited by Apollo 12 astronauts Charles Conrad and Alan Bean.

22. Surveyor was the first American spacecraft to employ retro-rocket techniques for soft-landing on another planet. Since the Moon has no atmosphere, aerodynamic landings using wings are not possible. Instead, the seven Surveyors used large rocket engines which, fired against the direction of motion, reduced the speed from over two miles per second to a near standstill just above the surface. They were controlled by radar systems on the spacecraft. Some of the parts of Surveyor 3 were later taken back to Earth with the Apollo 12 astronauts.

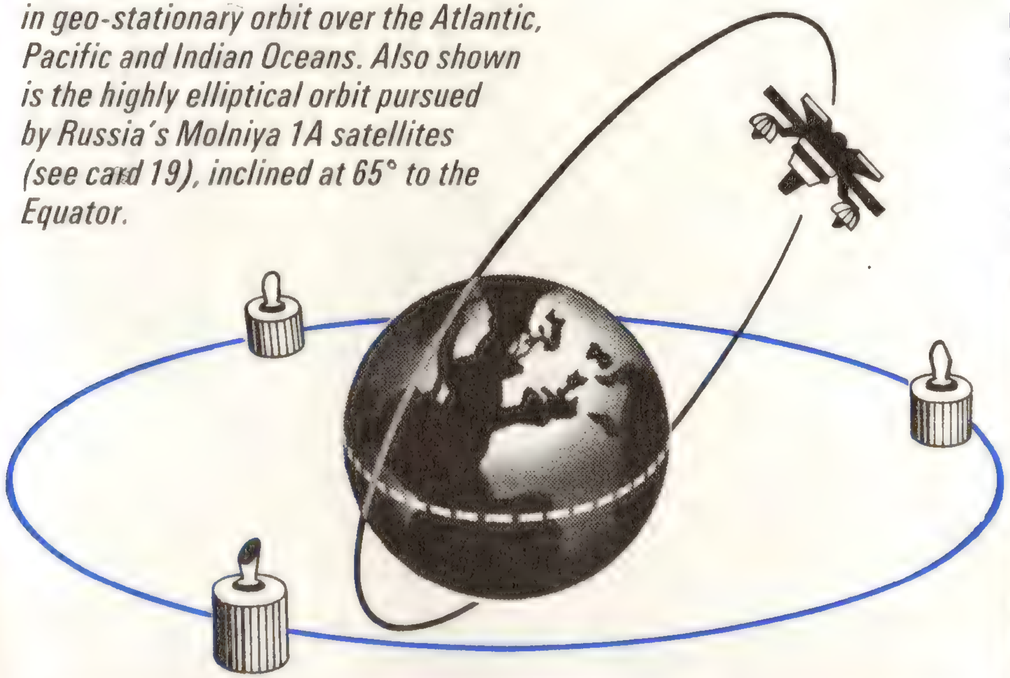


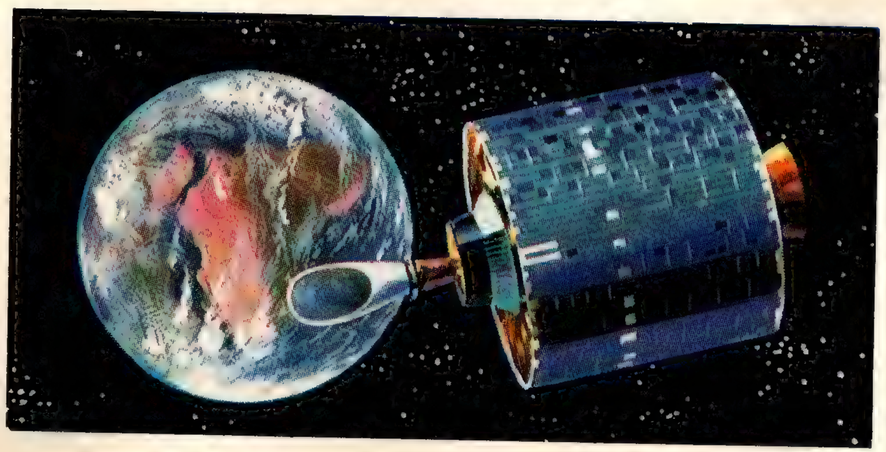
23. *Lunar Orbiter is a typical example of a spacecraft designed for the scientific survey of another heavenly body.* Large solar panels, which folded for stowage within the launch vehicle, generated electrical power for the spacecraft systems. The craft had to be capable of being pointed, on command, to selected areas of the Moon in order to photograph them, and also to the Sun for the solar cells to operate. Sun and star trackers were provided for this purpose. A temperature-control system ensured that the heat generated by the equipment was dissipated harmlessly. The film was developed automatically, and a scanning system translated the pictures into electrical signals which were transmitted to the Deep Space Network on Earth via the S-band communication system and the dish-shaped aerial.



23. Lunar Orbiter. Five Lunar Orbiters were built to map the Moon's surface and enable suitable sites to be selected for the American manned Moon-landings planned for Apollo. The first was launched from Cape Kennedy on Aug. 10, 1966. From its lunar orbit, the 853 lb. Orbiter returned pictures of the Moon for 19 days. The other Orbiters, launched on 6 Nov. 1966, 4 Feb. 1967, 4 May 1967 and 1 Aug. 1967, were all successful. Each was commanded (or allowed) to crash on the Moon after its work was done, to prevent it interfering with the Apollo flights.

The illustration shows the distribution of three Intelsat 3 communications satellites in geo-stationary orbit over the Atlantic, Pacific and Indian Oceans. Also shown is the highly elliptical orbit pursued by Russia's Molniya 1A satellites (see card 19), inclined at 65° to the Equator.

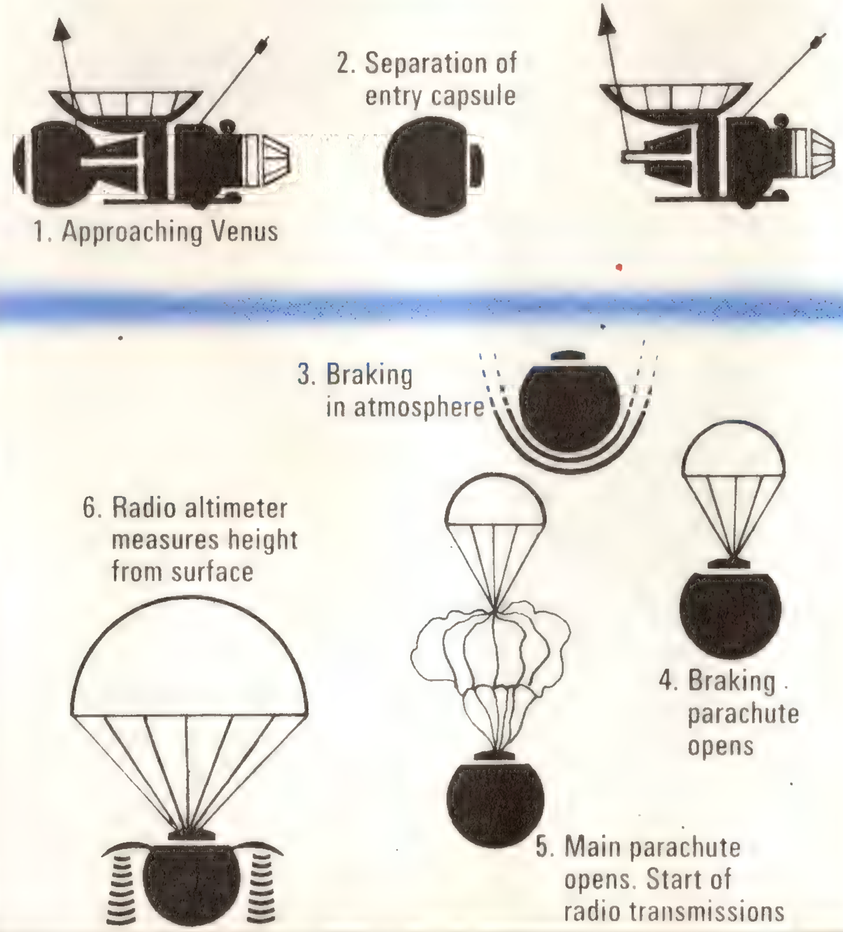


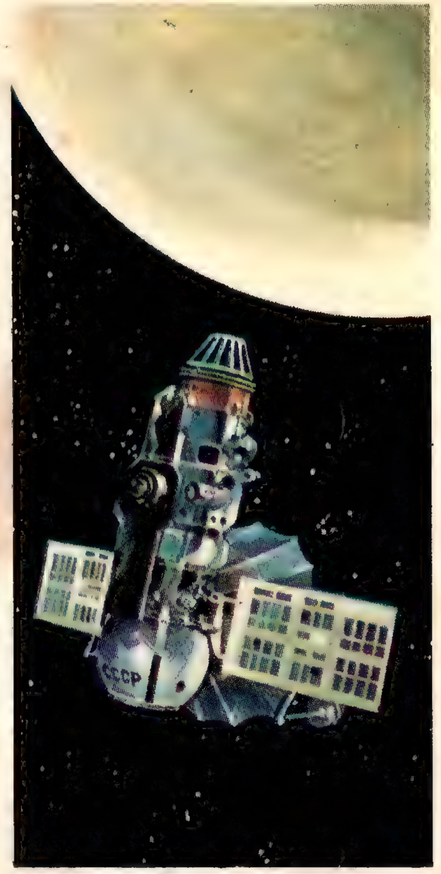


24. Intelsat 3. Following the outstanding success of the Early Bird and Intelsat 2 satellites, the first of a global series of eight communication satellites built for the 70-nation International Communication Satellite Consortium was launched from Cape Kennedy on Dec. 19, 1968. The 322 lb drum-shaped satellite was placed in a stationary orbit 22,300 miles above the Equator just off the coast of Brazil, from where it can relay 1,200 telephone conversations or four television channels between America and Europe. It began work on Dec. 24, 1968 with a TV broadcast by Pope Paul.

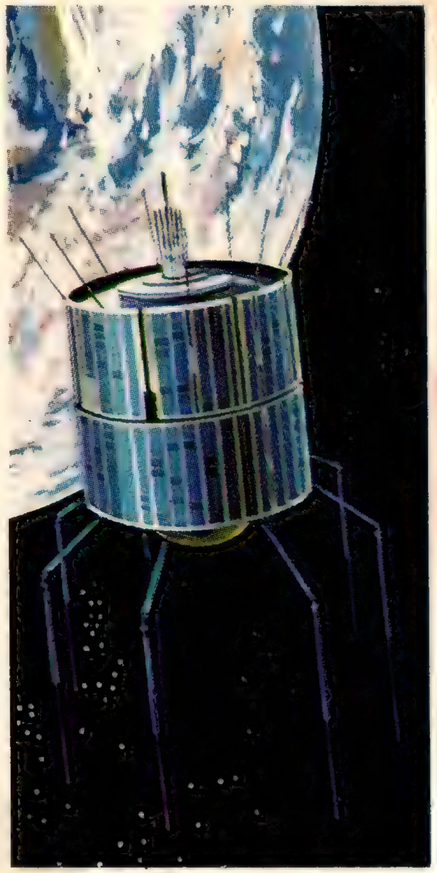
24. The speed of a satellite in orbit around the Earth depends upon its altitude above the ground. At a height of 22,300 miles, the speed is such that a satellite takes exactly one day to make one rotation, and (provided the orbit is parallel to the Equator) the satellite appears to remain stationary in the sky. It is then said to be in geo-stationary, geo-synchronous, synchronous or stationary orbit. A system of three satellites at this height can provide nearly world-wide radio or TV coverage.

25. All three capsules stopped transmitting before they could soft-land. Probably the immense atmospheric pressure pushed in the covers of their radio compartments. According to the USSR Academy of Sciences, the surface pressure of Venus may reach 100 atmospheres and the temperature 500 C.





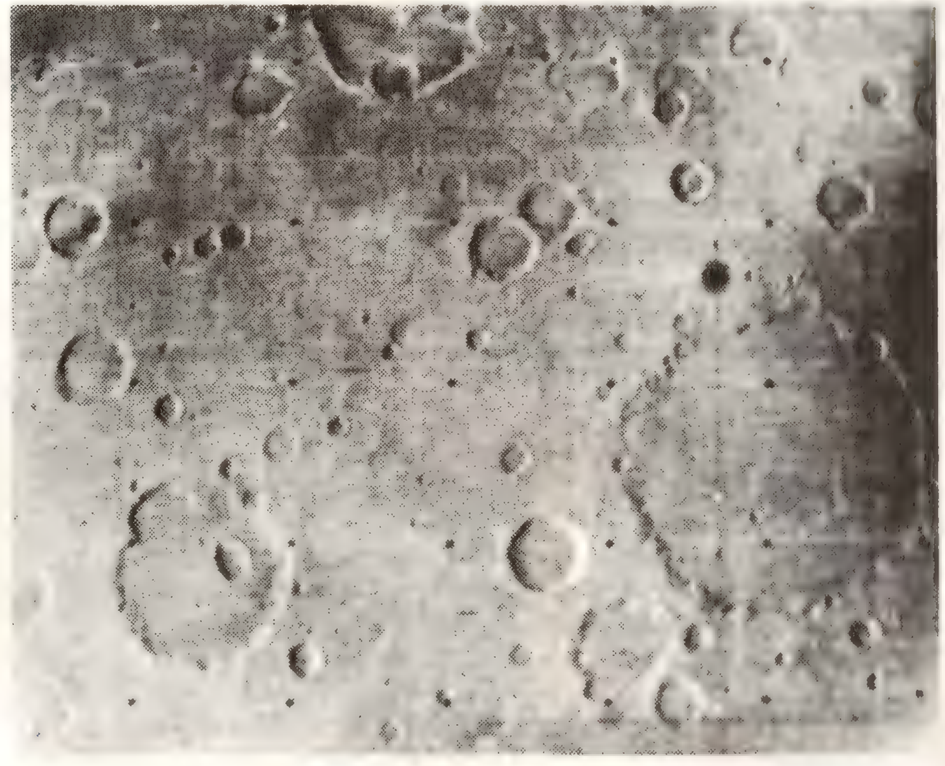
25. Venera. Russia's enormous triumph of parachuting instrument capsules into the dense atmosphere of Venus was first achieved on Oct. 18, 1967. After a journey of 217 million miles, a 3¼ ft dia. 844 lb capsule detached itself from the 1,595 lb spacecraft and started its descent. Following a period of aerodynamic braking, it released a high-temperature parachute and simultaneously radio signals streamed back to Earth. Similar Venera 5 and 6 spacecraft arrived on May 16 and 17, 1969 respectively. According to data received, the atmosphere consists of 97% carbon dioxide with small amounts of water vapour, oxygen and nitrogen; when signals ceased several miles above the surface, pressure was 27 atmospheres and temperature 320°C.

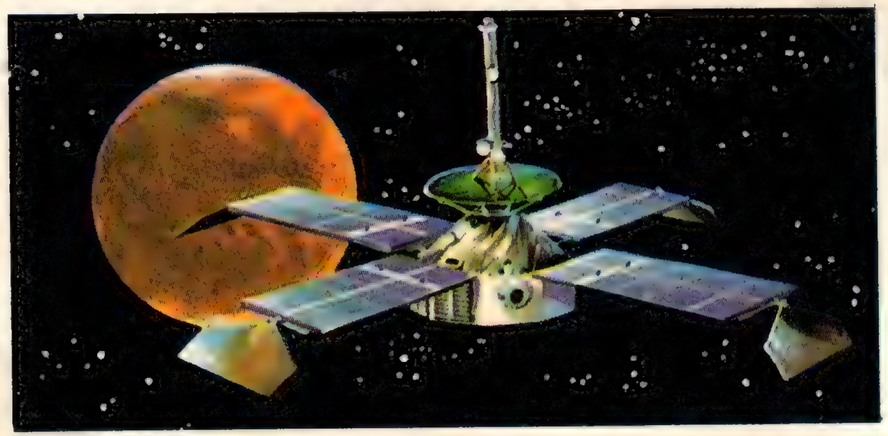


26. ATS-3. Third in the series of American applications technology satellites, ATS-3 was launched by an Atlas-Agena rocket from Cape Kennedy on Nov. 5, 1967 into a stationary orbit 22,300 miles over the Atlantic, off the coast of Brazil. The 805lb satellite, with a diameter of 57.6in and a length of 60in, was designed to investigate ways of using satellites for improving weather forecasting and long-range communications. It was noteworthy for returning a large number of excellent colour pictures of the Earth, and for its participation in televising the Pope's visit to Bogota, and the Olympic Games in Mexico in 1968; also the first Moon landing in 1969. ATS-3 was the only NASA comsat which could handle high quality colour television from the 16 ft dia. mobile ground stations.

26. The term 'application satellite' is generally used for those designed for purposes other than scientific. The Early Bird (radio and television), Tiros and Nimbus (weather) and Transit (navigation) satellites are all examples of applications satellites. Applications Technology Satellites form a continuing series which are designed, not for operational use, but to improve the techniques developed for existing satellites. Solar cells, stabilisation devices, advanced communication systems, high-resolution cameras—all these have to be tested and evaluated under real-life conditions before their reliability and performance can be predicted with confidence.

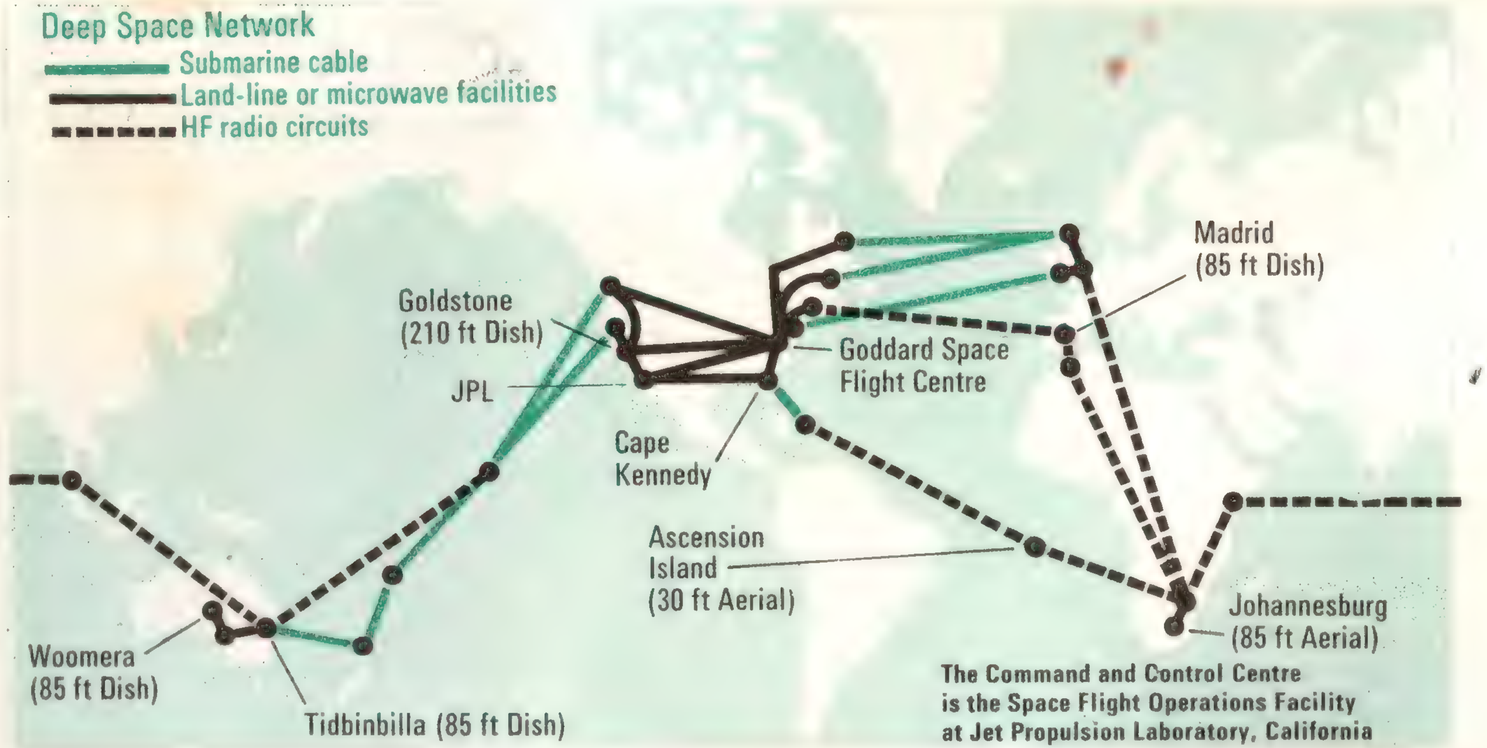
27. The first spacecraft in the series designed for unmanned exploration of the Earth's nearest neighbours in the solar system was Mariner 2, launched towards Venus on Aug. 26, 1962. One hundred and nine days later it flew past the planet, radioing back readings of temperatures and pressures of the blindingly white cloud which perpetually obscures the surface. A second Venus probe, Mariner 5 was flown on June14, 1967.
On Nov. 28, 1964, the first American Mars probe was launched, and the historic flight of Mariner 4 has since been followed by Mariners 6 and 7. These two probes were better equipped, with two TV cameras each in place of one on Mariner 4. Mariner 6, launched from Cape Kennedy on Feb. 24, 1969, flew past Mars at a distance of 2,131 miles on July 31. Its twin, Mariner 7, left Cape Kennedy on Mar. 27, 1969, passing by Mars at the same range.
Several hundred pictures of the surface, covering 20 times the area of the Mariner 4 photos, were obtained, together with measurements of the constitution, density and temperature of the atmosphere. As a result, three types of surface have been identified: 1) containing Moon-like craters (although considerably eroded, as in the illustration), 2) areas apparently smooth and featureless. 3) chaotic terrain. Two further spacecraft, Mariners 8 and 9, will be launched in 1971 to circle Mars for periods of three months and map the surface in preparation for the Viking unmanned lander-spacecraft of 1975.



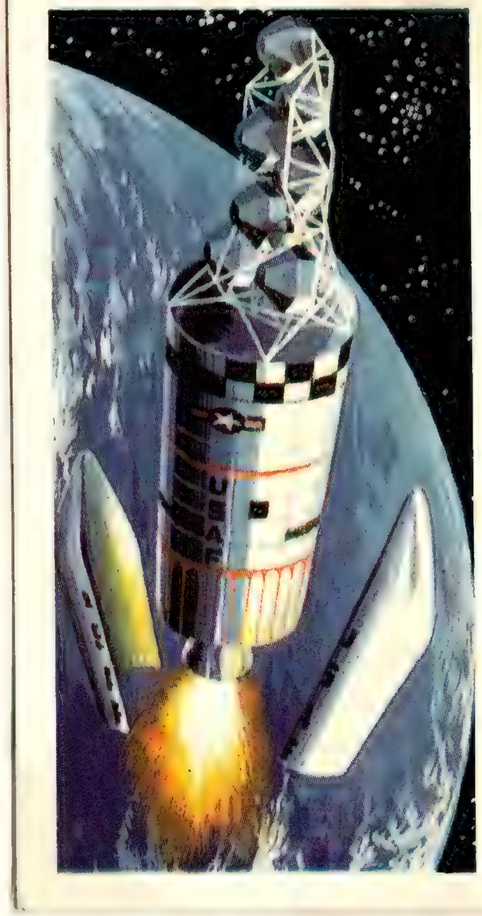


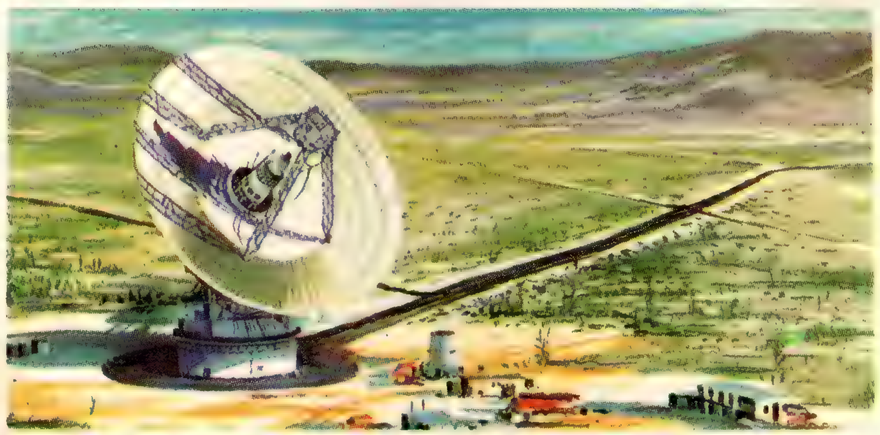
27. Mariner 4. The flight of the American Mariner 4 spacecraft was the first successful mission to Mars. Launched from Cape Kennedy on Nov. 28, 1964, the 575 lb spacecraft flew past the planet at a range of 6,116 miles on the following July 15. The 21 TV pictures revealed for the first time the existence of craters similar to those of the Moon. It was the first time that a member of the solar system, other than the Moon, had been photographed by a spacecraft. Each picture took over eight hours to transmit, due to the weakness of the signal received on Earth.

28. Signals from small transmitters on interplanetary spacecraft such as Mariner are very weak when they reach the Earth, and some flights require that the spacecraft be kept in view for long periods at a time. NASA's world-wide receiving and communication system, the Deep Space Network, has Earth stations at Tidbinbilla and Woomera in Australia, Johannesburg, Madrid and Ascension Island, all connected with the master station at Goldstone by way of micro-wave links, land-lines or submarine cable.

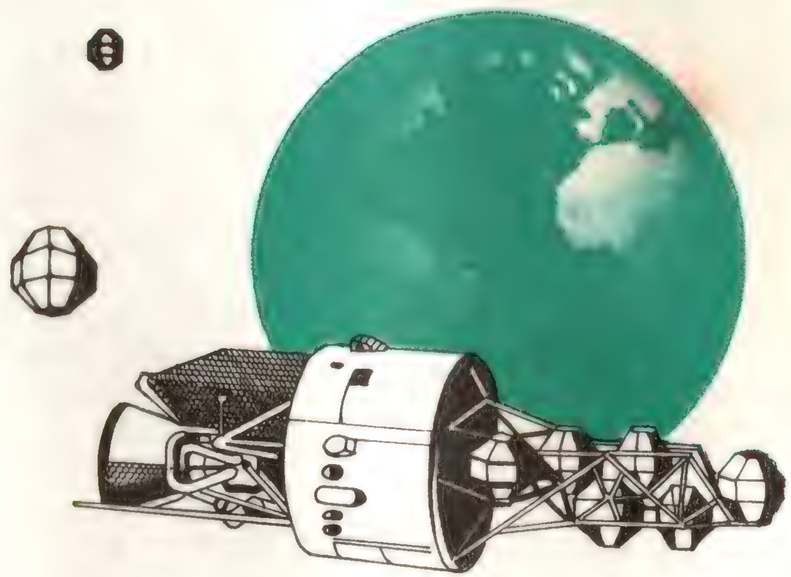


The Command and Control Centre is the Space Flight Operations Facility at Jet Propulsion Laboratory, California





28. The Goldstone Mars Station. The 210ft dia. aerial and its tracking station was built by NASA as the main element of its deep-space tracking network. The Mars station is located at Goldstone in the lonely Mojave Desert in California. Man-made electrical interference, which would swamp extremely weak signals from unmanned spacecraft at the boundary of the Solar System, is here almost absent. In August 1969 commands were sent 60 million miles to Mariners 6 and 7, to photograph Mars from a range of 2,000 miles and transmit television pictures of it back to Goldstone.



Titan transtage distributing the IDCSP satellites.

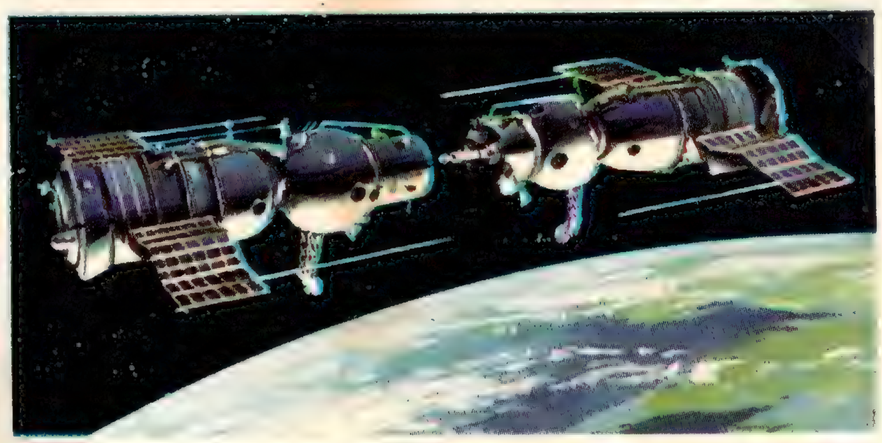
29. Defence Satellites. The need for a system to provide strategic or tactical communication to her armed forces throughout the world gave rise to the American project known as IDCSP, the Interim Defence Communication Satellite Programme. A network of 26 satellites was established between 1967 and 1968, and this has provided a temporary capability, pending the introduction of a fully operational system. It has also provided a basis for research and development. The 100lb satellites were launched into near-synchronous orbits, up to eight at a time, by Titan 3 rockets. At least one satellite is always in view of any given ground station. Future military comsats will be of the geo-stationary type, where the main advantage is the need for fewer satellites.

30. Soviet deep space tracking station in the Crimea.

Vladimir Komarov

Georgi Beregovoi

31. Vladimir Komarov lost his life while testing the Soyuz 1 spacecraft in Apr. 1967. After completing 17 orbits the capsule re-entered the atmosphere; but when the parachute was ejected at more than 4 miles above the Earth, it failed to open properly. The craft plunged to destruction 'on the steppes of Orenburg.' A simple monument now marks the spot. Next to test a spacecraft of this type was Georgi Beregovoi who was launched in Soyuz 3 on Oct. 26, 1968. The unmanned Soyuz 2, launched the day before, was used as a 'target' for experiments in orbital rendezvous, but the two vehicles did not dock. Beregovoi's 64 orbits of the Earth lasted 94 hr 51 min.
The first automatic docking between orbiting unmanned spacecraft had been achieved by Soviet spacecraft—Cosmos 186/188 in Oct. 1967 and Cosmos 212/213 in Apr. 1968.

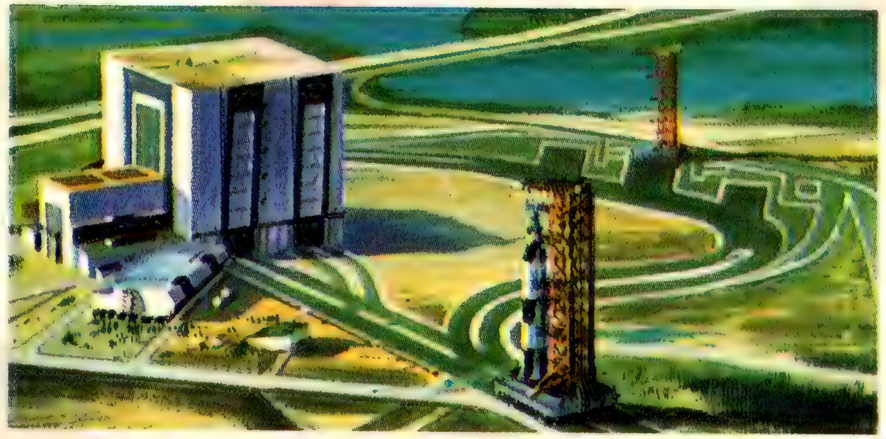


31. Soyuz. The three-part Soyuz spacecraft – used to develop space station techniques – comprise a spherical experiment compartment, a re-entry module and a rocket-powered service module. The experiment compartment, as well as allowing men to perform scientific and technological experiments (e.g. vacuum welding under weightlessness in Soyuz 6), can be separately de-pressurized to form an airlock allowing cosmonauts to emerge into space. After docking two men transferred from Soyuz 5 to Soyuz 4 in orbit returning to Earth in a different craft.

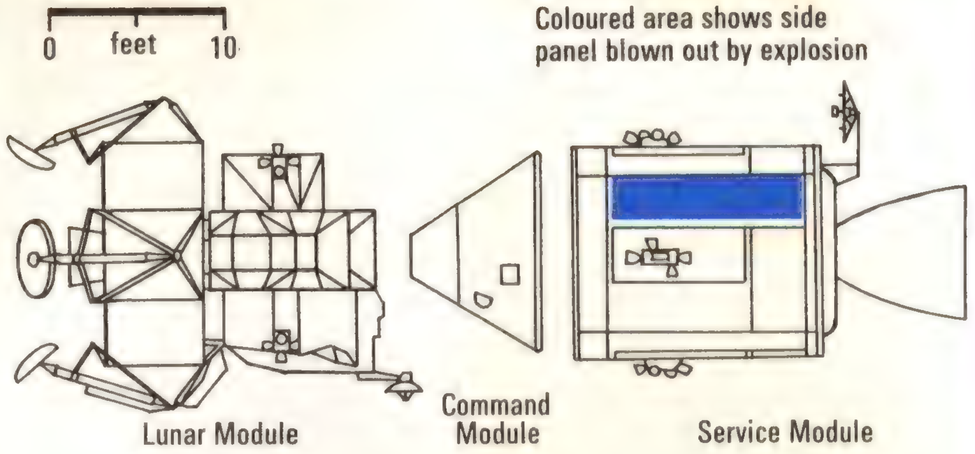
30. Soviet Space Tracking. Stations in the Soviet Union are backed up by a fleet of tracking ships in the Atlantic, Pacific and Indian Oceans. One, the '*Cosmonaut Vladimir Komarov*', is named after the spaceman who lost his life in the Soyuz 1 landing accident. It was built at the Baltisky shipyards in Leningrad for the USSR Academy of Sciences. Land-based tracking stations are located in various parts of the Soviet Union. The main deep space tracking centre, which maintains contact with space probes en-route to Venus and Mars, is Yevpatoria in the Crimea.

32

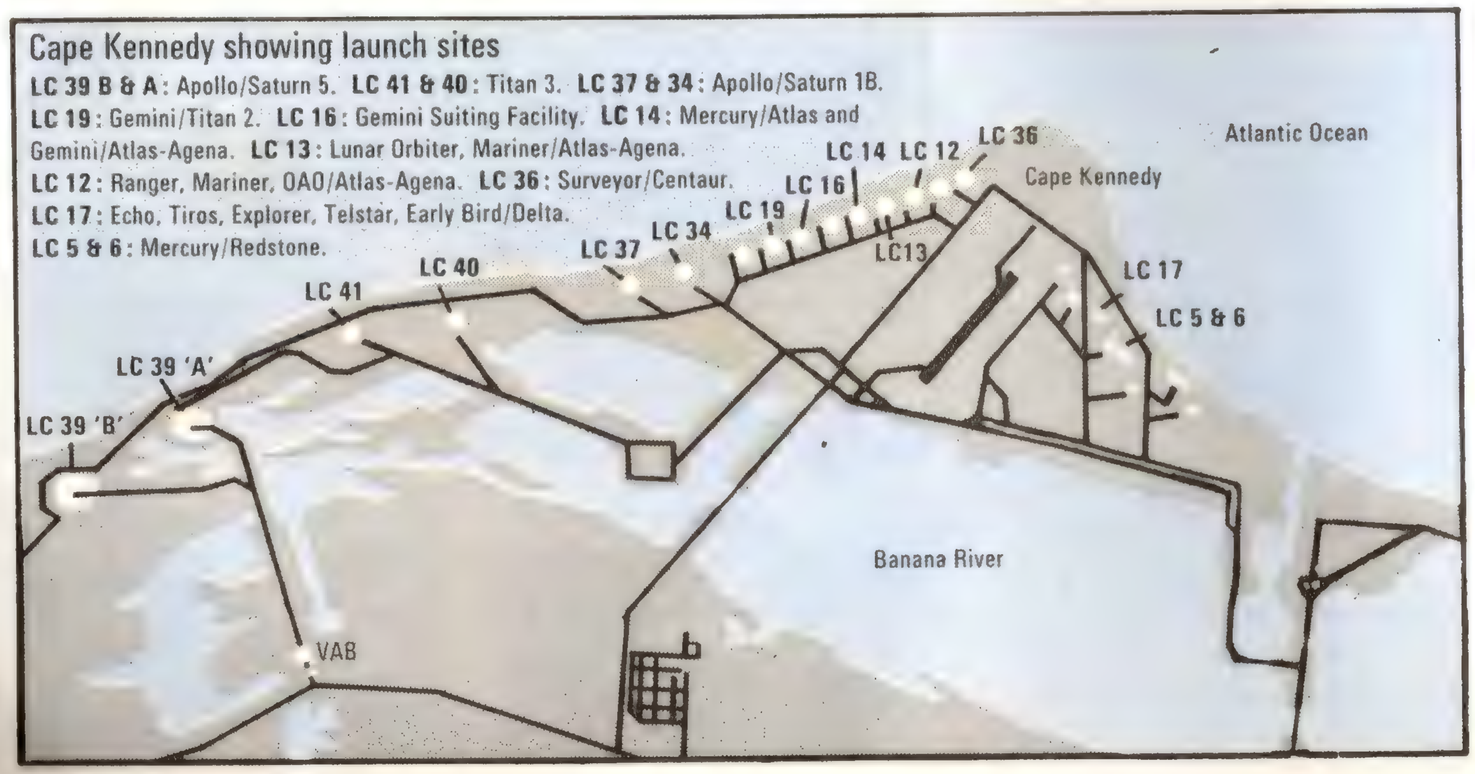
32. Soyuz Recovery. Russia has from the beginning recovered her cosmonauts on land rather than the ocean. An ejection seat in Vostok spacecraft let the cosmonaut and re-entry capsule parachute to Earth separately; only Gagarin remained inside the capsule for what must have been a 'heavy' landing. The 3-man Voskhod and Soyuz spacecraft had no ejection seats. After re-entering the atmosphere from space, their capsules were brought to Earth by a single large parachute and when only 3 to 4 feet from the ground touchdown was cushioned by retro-rockets.

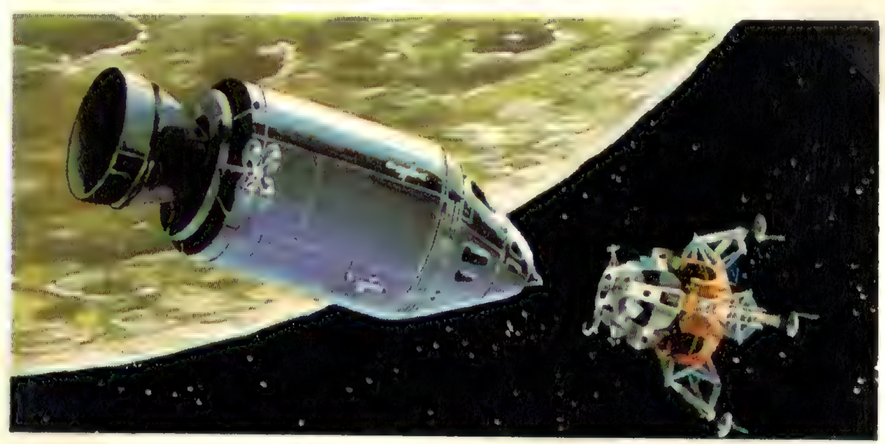


33. Saturn V at Cape Kennedy. The complex task of assembling and testing the 3,000 ton, 363ft high Saturn V Moon-rocket, and the time involved, has made it necessary to conduct this operation away from the launch pad in a special Vehicle Assembly Building. The complete rocket, mounted on a special mobile launch tower, is transported bodily from the VAB to the launch pad three miles away on a huge tracked crawler vehicle. The rocket and its launch tower are deposited at the launch pad, the crawler withdraws, and final tests are made, preparatory to fuelling and launching.

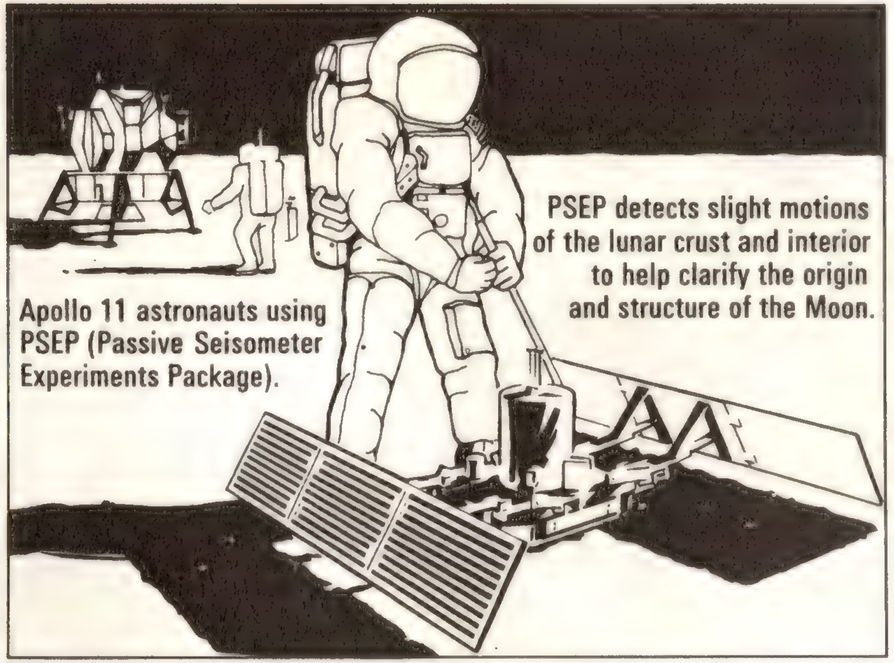


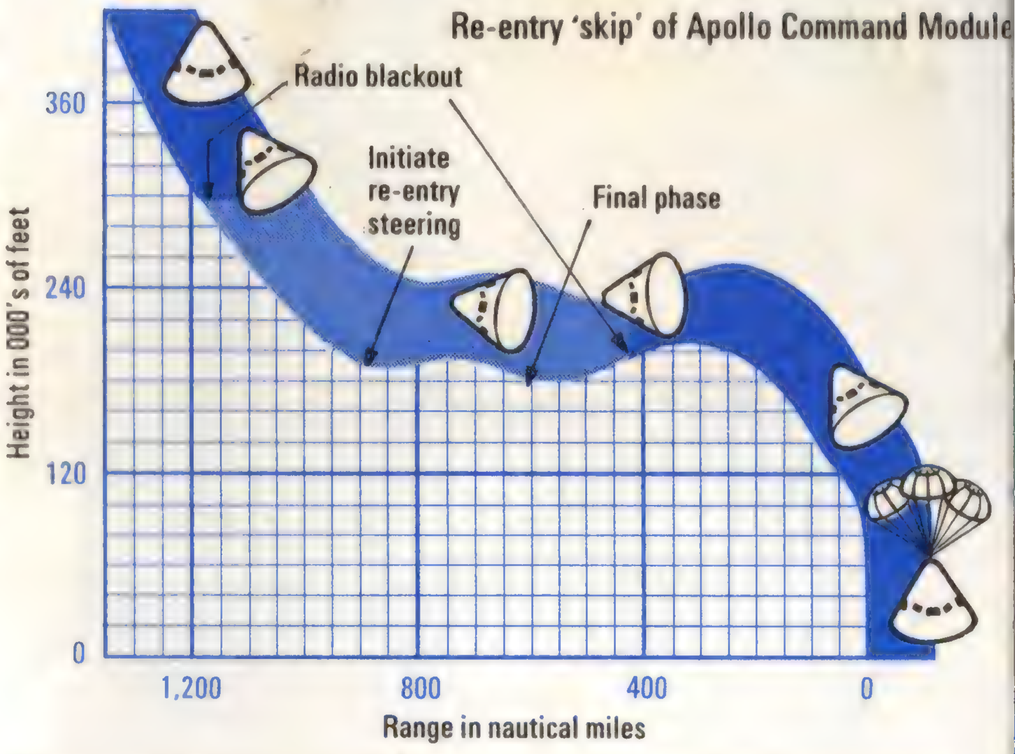
34. A near-disaster to the Apollo 13 spacecraft some 200,000 miles from Earth on Apr. 14, 1970 almost cost James Lovell, Fred Haise and John Swigert their lives. An oxygen tank feeding fuel cells in the service module exploded cutting off all power and oxygen. Immediately, Houston Mission Control put into effect emergency plans to get the astronauts home. The lunar module—which was to have landed Lovell and Haise near the Moon's Fra Mauro formation—was still attached and the crew drew upon its electricity and oxygen. Using the lunar module's engine to adjust the flight path, Apollo 13 was changed to a free-return lunar trajectory. Some 90 hours after the explosion—the damaged service module was jettisoned followed by the 'lifeboat' lunar module, and to the relief of millions watching on TV, the command module splashed down safely in the South Pacific just four miles from the carrier *Iwo Jima* at 19.07 BST on Apr. 17.





34. Apollo Command and Service Modules. After preliminary unmanned and manned experiments in Earth-orbit, Apollo 8 carried Frank Borman, James Lovell and William Anders on man's first flight around the Moon and back at Christmas 1968. The two-part spacecraft comprises a 13,000 lb command module containing the crew, and a 53,000 lb service module with oxygen, power supply and a rocket engine for in-flight propulsion and braking. During lunar landing missions, the craft waits in lunar orbit with one astronaut while two others descend in the Lunar Module.



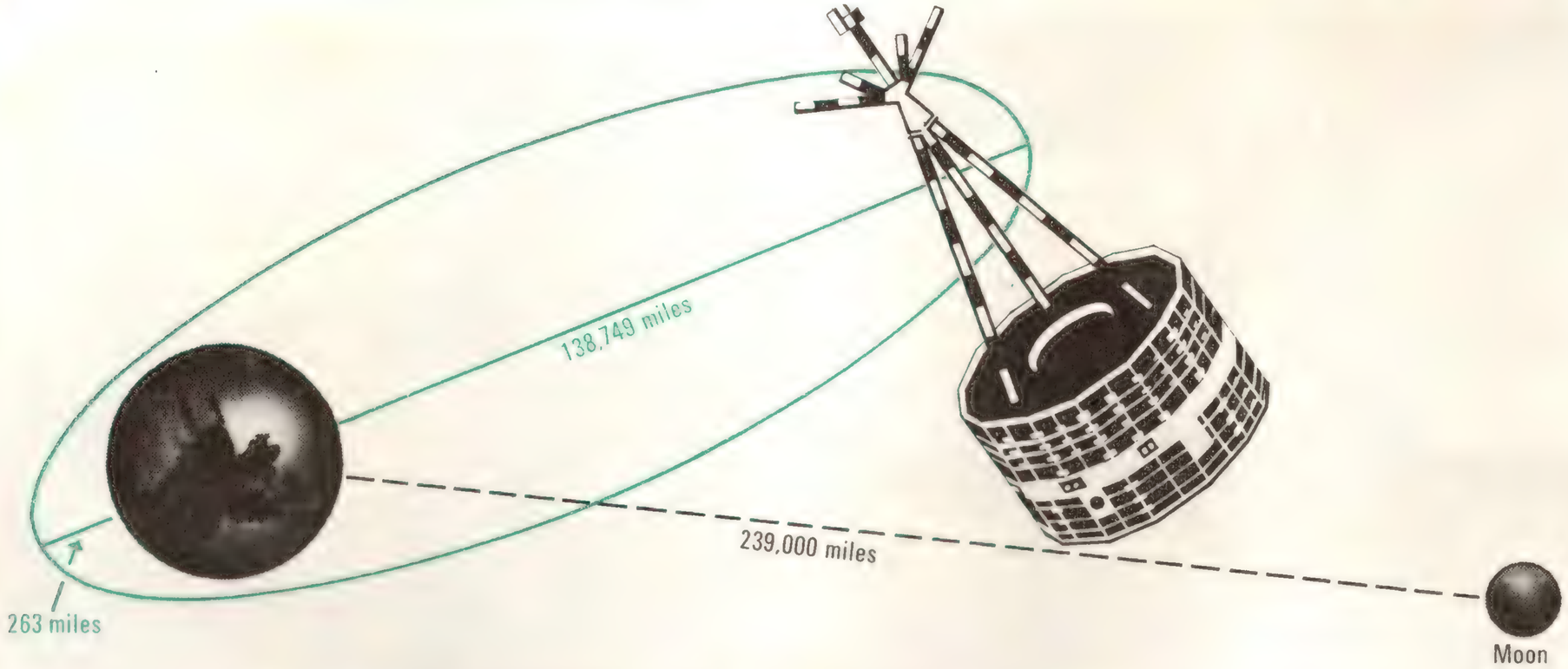


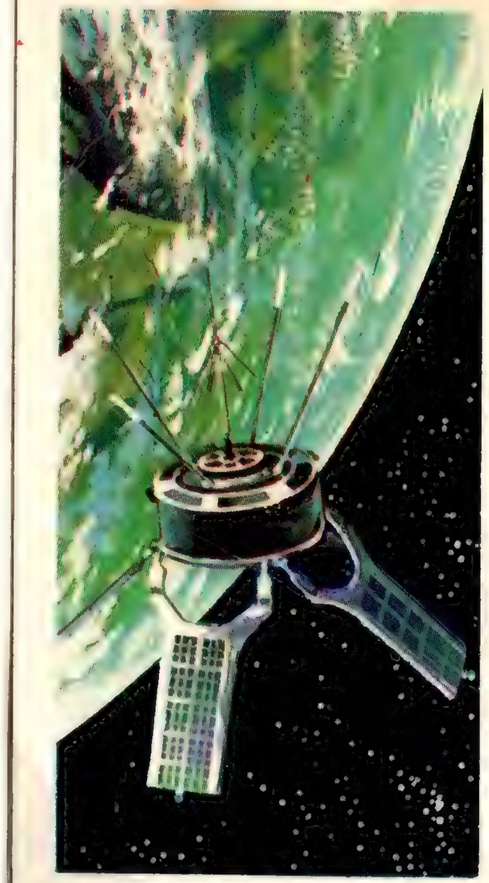
35. First men on the Moon were Neil Armstrong and Edwin Aldrin. They landed in the Apollo 11 lunar module (code name Eagle) in the Sea of Tranquillity at 21 hr 17 min 42 sec BST on July 20, 1969. Standing by to retrieve them in lunar orbit was the command ship Columbia with Michael Collins.

35. Apollo Lunar Module. Specially designed to land on the Moon, the 32,500 lb Lunar Module operates in conjunction with the Apollo Command and Service Modules from which two of three astronauts transfer in lunar orbit. After separating from the parent, speed is reduced by the descent engine and the craft falls on a curved path towards the lunar surface. Arriving near the landing site the astronauts override the automatic control system to achieve a vertical soft-landing 'on the hover'. Leaving the Moon the astronauts blast-off in the ascent stage of the LM using the four-legged descent stage as a launch platform. They must rejoin the orbiting parent spacecraft to return home. The first lunar landing was made by Neil Armstrong and Edwin Aldrin on July 20, 1969.

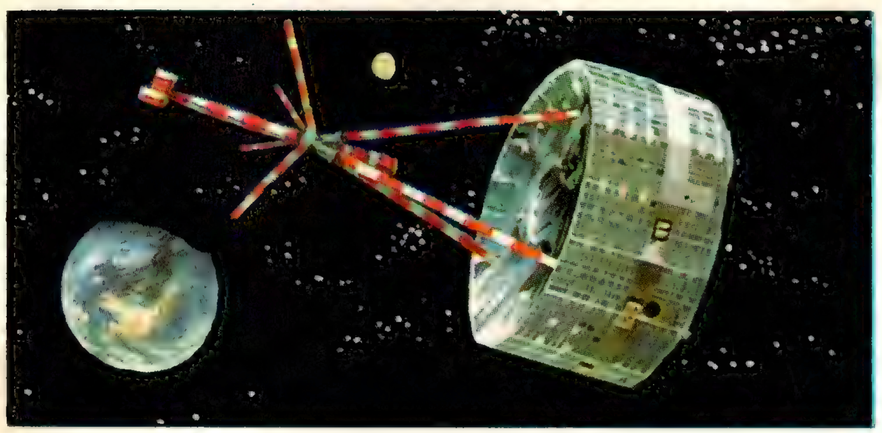
36. The command module returning from a lunar voyage attains a speed of about 25,000 m.p.h. as it nears the Earth. At a height of about 400,000ft., the atmosphere, (thin as it is at this altitude), is sufficient to cause a deceleration of about 0.05g in the spacecraft, which is then some 1,400 miles from splashdown; this is the beginning of re-entry. The command module loses 200,000 ft of altitude in the next 500 miles, during which the heat shield glows white hot, and the deceleration builds up to 4g. This intense heating changes the behaviour of the air ahead of the spacecraft, and radio communications with Earth are temporarily cut off. A flight path which imposes a constant 4g retardation is flown, which results in a 'switchback' shape; the command module actually generates lift, just like an aeroplane wing, although much less compared with its weight.

36. Apollo Parachute Recovery. The recovery of the Apollo command module appears crude. But the main problem is to dissipate safely the enormous energy which the spacecraft acquires during its return to Earth, and this can only be done by using the atmosphere as a brake. To prevent the vehicle being destroyed by excessive heating, it is formed like a cone. Such shapes cannot, of course be manoeuvred to a conventional kind of landing like an aeroplane. The three main parachutes open at about 10,000ft, lowering the spacecraft gently to the water.





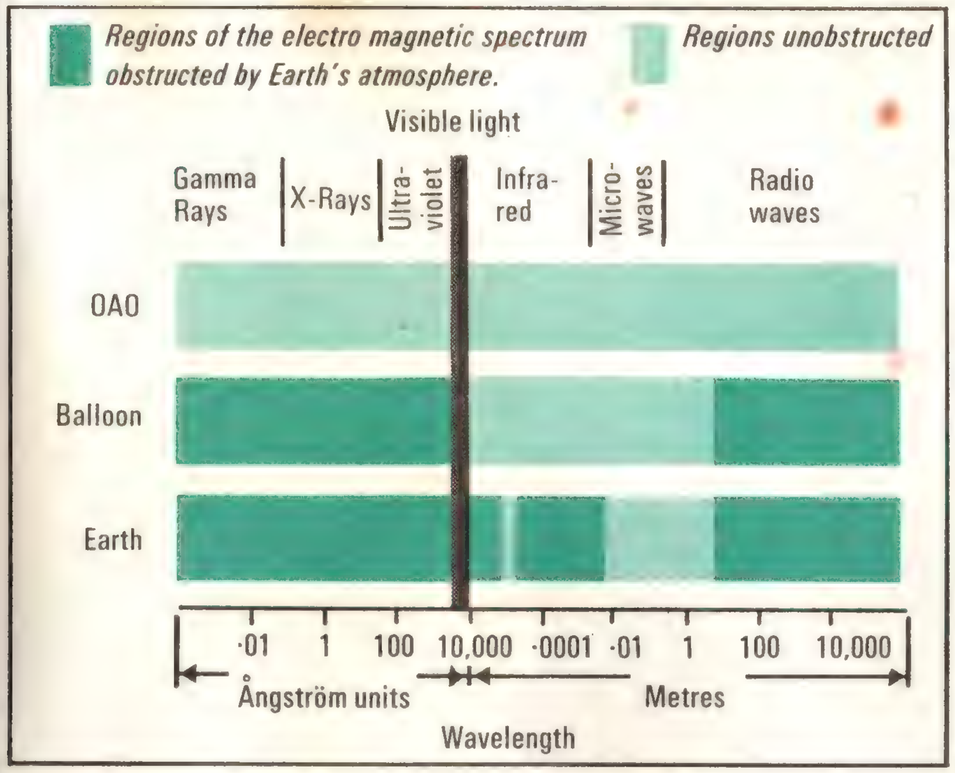
38. Asterix-Diadème. France became the third nation after Russia and America to launch a satellite on Nov. 26, 1965. Having lifted-off from a launch pad at Hammaguir in the Sahara, the three-stage Diamant A injected an 86lb test-satellite Asterix 1 into a 327-1,123 mile orbit inclined at 34.24° to the Equator. This experiment qualified the launcher for further missions. Three more satellites followed from Hammaguir—Diapason 1 on Feb. 17, 1966; Diadème 1 on Feb. 8, 1967 and Diadème 2 on Feb. 15, 1967. Then France had to vacate the Sahara range under the terms of the Evian treaty with Algeria. It was more than three years before France resumed satellite launching—with Diamant B—from a new equatorial launch centre at Kourou in French Guiana.



37. HEOS. (Highly Eccentric Orbit Satellite). The third spacecraft built by the European Space Research Organisation, and the first deep space probe built outside America and Russia. The 238 lb. spacecraft was launched by a Delta rocket from Cape Kennedy on Dec. 5, 1968. Its very elliptical orbit takes it as far as 138,749miles from the Earth, and as near as 263 miles. HEOS was designed to investigate interplanetary space during the Sun's period of maximum activity, which occurs every eleven years. Of the eight experiments on board, three were provided by British universities.

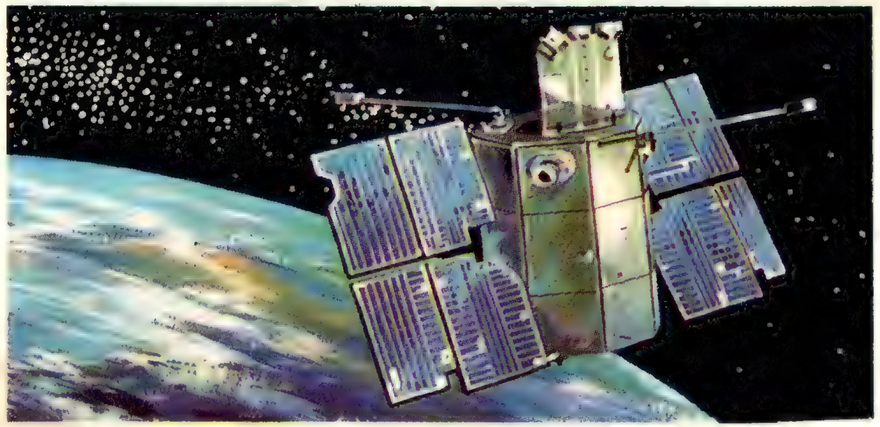
37. ESRO, the European Space Research Organisation, is an association of ten countries: Britain, Germany, France, Italy, Sweden, Belgium, The Netherlands, Switzerland, Spain and Denmark. It was formed in 1962 to enable the undertaking of scientific space programmes which would have been beyond the resources of any single European country. Each member supports the agreed programmes in proportion to its national income, except Britain, which pays the largest share, 25 per cent. By Apr. 1970 four satellites or spacecraft had been launched into Earth orbit, all using American rockets. They were: Iris (ESRO 2b), May 17, 1968 (the first satellite, ESRO 2, was destroyed in a launch vehicle failure); Aurorae (ESRO 1), Oct. 3, 1968; HEOS (shown here), Dec. 5, 1968; and Boreas (ESRO 1b), Oct. 1, 1969.

38. France has taken out co-operative agreements with America's National Aeronautics and Space Administration and Russia's Academy of Sciences. The first French satellite to be launched internationally was the 132 lb FR-1 sent into orbit by a Scout rocket from Vandenberg on Dec. 6, 1965.

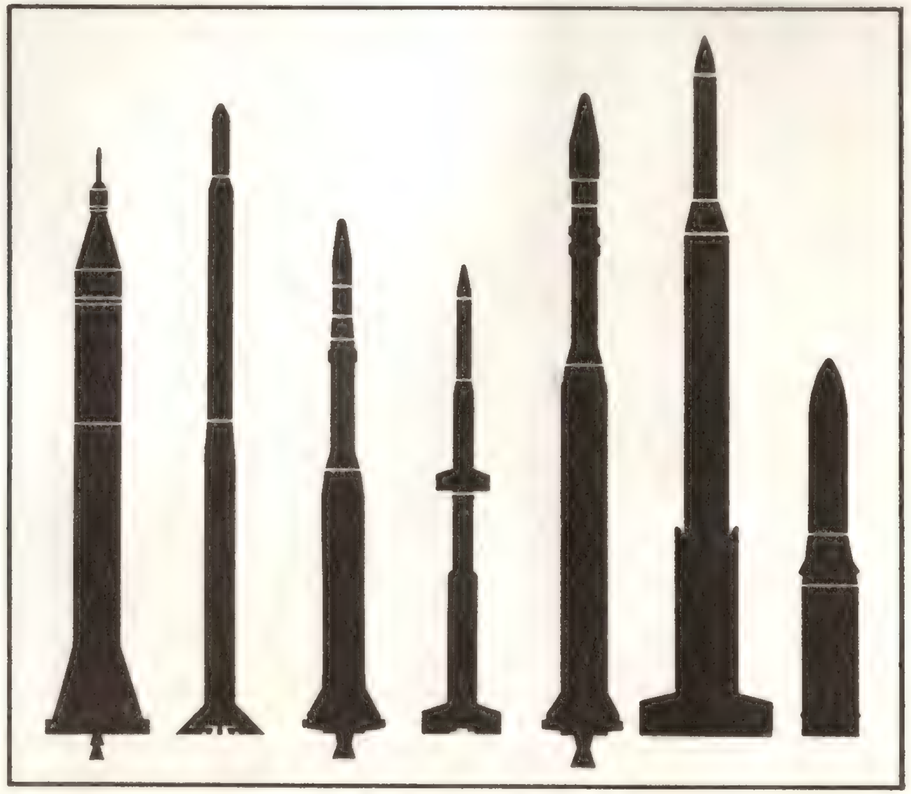


39. The enormous advantage of being able to 'see' stars in wavelengths other than those accessible to the human eye have only quite recently been appreciated. New-born stars, perhaps only 75,000 years old, may have surface temperatures of as much as 50,000°C. Under these conditions the majority of the radiation occurs in the ultraviolet region. By analogy, on the other side of the spectrum, the heat from an electric fire can be felt before the filament becomes visible, showing that, at very low temperatures, the radiation is mainly in the form of infra-red, which has good heating qualities. Ultraviolet is largely absorbed by the Earth's atmosphere, and so Orbiting Astronomical Observatories are launched to pick it up in space where no such attenuation takes place.

40. Small satellite launchers compared to scale.
Left to right, Juno 1/Jupiter C (USA); Scout (USA); Diamant A (France); Lambda 4S (Japan); Diamant B (France); Mu-4S (Japan) and Black Arrow (UK). No details of the rocket that launched China's 381 lb satellite on Apr. 24, 1970 were immediately available.



39. Orbiting Astronomical Observatory 2. One of the most complex unmanned satellites to be developed by the West, OAO-2 was launched by Atlas-Centaur from Cape Kennedy on Dec. 7, 1968. It contains two experiments, designed by American universities, for the examination of stars and galaxies by means of their ultraviolet radiation. From 480 miles above the Earth, it can measure radiation which never reaches the Earth's surface. Its importance has been equated with that of the optical telescope, invented over 350 years ago. OAO-2 weighs 4,446 lb, spans 80in. and is 118in. long.



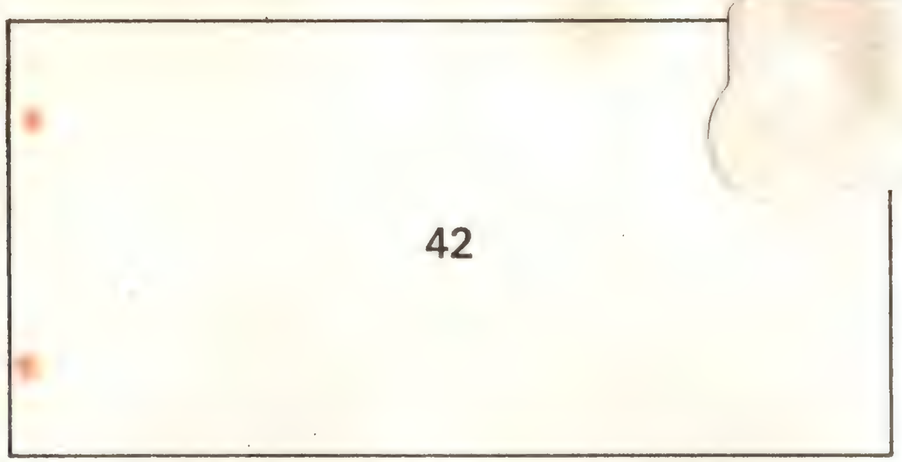
40. Small Space Launchers. Space programmes are no longer restricted to the major powers. France got into orbit with her Diamant A rocket from the Sahara in Nov. 1965, and Japan with Lambda 4-S from the Uchinoura Space Centre in Feb. 1970, following with the larger Mu satellite launcher (illustrated). China's first satellite, 381 lb, was launched in Apr. 1970. Britain's Black Arrow programme is launched from Woomera in South Australia. France has now opened a new equatorial launch centre in French Guiana for her second-generation Diament B rocket which can place a 220 lb satellite into a 370 mile circular orbit. The smaller countries have also found it expedient to have satellites and instruments launched as part of international programmes by the United States and the Soviet Union.

41. An improved rocket—Europa 2—will place communications satellites into geo-stationary orbit from an equatorial launch centre at Kourou in French Guiana. Britain's Blue Streak was dropped from plans to develop a third-generation launcher, Europa 3, because of lack of interest by the UK Government. The new launcher will have a French first stage and a German second stage of entirely new design. It will place 5 tonne payloads into low Earth orbit or 700 -900 kg (1,543-1,984 lb) into geo-stationary orbit.

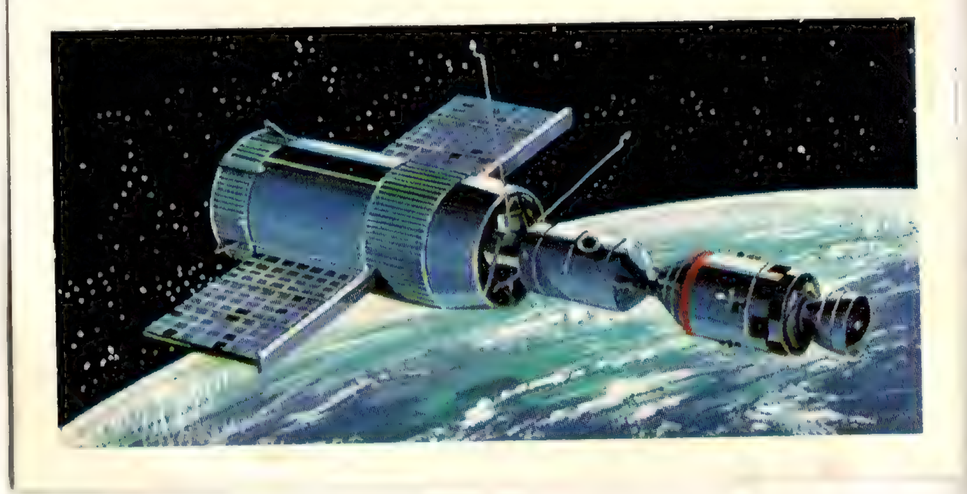
41. Europa 1. Europe's bid to gain independence in space began with the formation of the European Launcher Development Organisation in 1962. The object was to produce a rocket that would place a 1,760 lb satellite into polar orbit at 300 miles altitude. Britain contributed Blue Streak—the abandoned ballistic missile—while France and West Germany built new 2nd and 3rd stages, Coralie and Astris. Italy provided test satellites and Holland and Belgium telemetry and tracking equipment. Australia made available the Woomera rocket range. Of 10 launchings only three were meant to orbit test-satellites. Blue Streak was successful on each occasion—with a last launching still to take place at this writing—but Coralie and Astris failed twice.

42. Personal vertical take-off and landing devices, maintained in flight by small downward-firing rocket motors, have also been devised for transporting astronauts on the Moon. They will travel much farther than on Earth because of the Moon's low gravity, and may eventually supplement the work of the LRV's with their top speed of only 10 m.p.h. on relatively level ground.

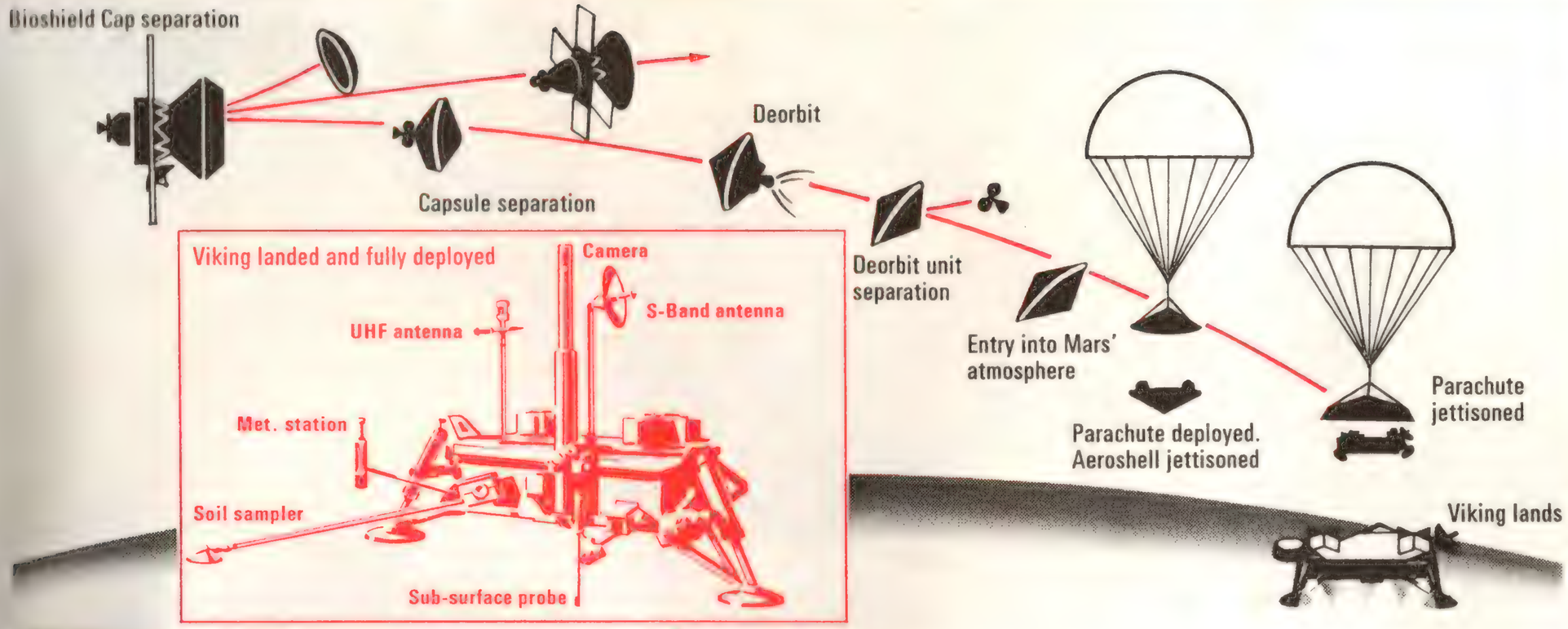
43. In contrast to the very limited space available for scientific research in the Apollo command module, the orbiting Skylab will provide no less than 10,000 cu.ft. in which the crew (three astronauts at any given time) may move around. Launched with the equipment installed on Skylab, America's first-generation space station, will be a large telescope for docking with the spacecraft. This telescope (not illustrated) will be mounted inside a specially adapted Apollo lunar-module ascent stage.
Its purpose is to allow observation of faint stars and galaxies above the turbulent layers of the Earth's atmosphere, which causes all objects to appear blurred.

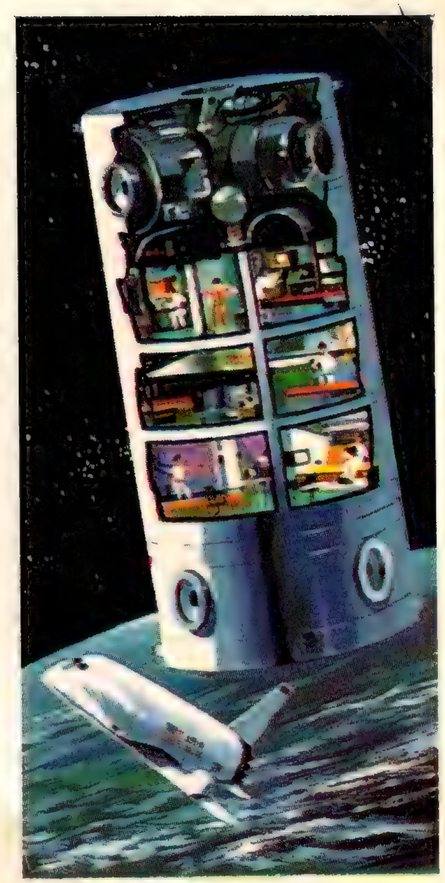


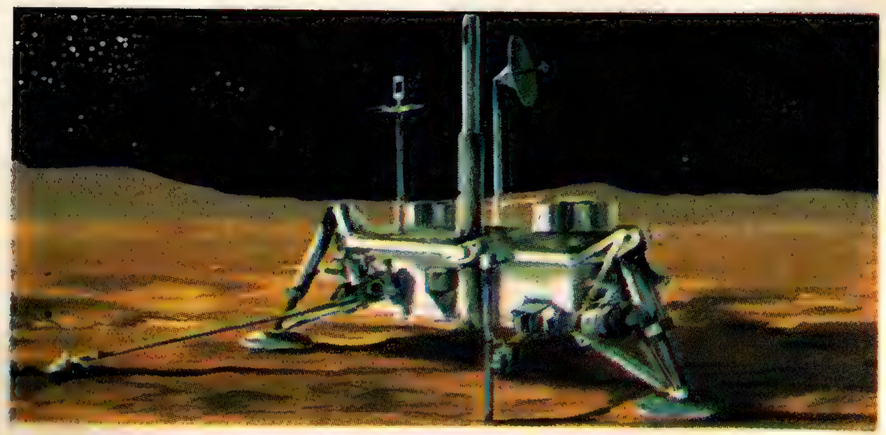
42. Lunar Roving Vehicle. Increased astronaut mobility on the Moon is possible with a Lunar Roving Vehicle (LRV) intended to be carried by Apollo 16, 17, 18 and 19. After being deployed from the Lunar Module, the electric-powered 'mooncar' will carry two astronauts and their equipment for a total of 75 miles, though for safety, operations will be kept to a radius of 3 miles from the spacecraft. The LRV has woven-wire wheels driven independently by separate electric motors, and can cross 28in. crevasses and climb slopes of up to 25° with a full load.



43. Skylab. This orbiting workshop is an extension of the Apollo Moon-landing techniques in which the third (S-IVB) stage of the Saturn V rocket is pre-equipped as a workshop/laboratory. It will be placed in Earth orbit by the first two Saturn V stages during 1972. Shortly after its launch, a crew of three in an Apollo command module will be launched by a Saturn IB to rendezvous with the workshop and begin a 28-day mission to gather scientific, technological and biological data. Two more 3-man crews will be flown up later to continue experiments for up to 56 days each.





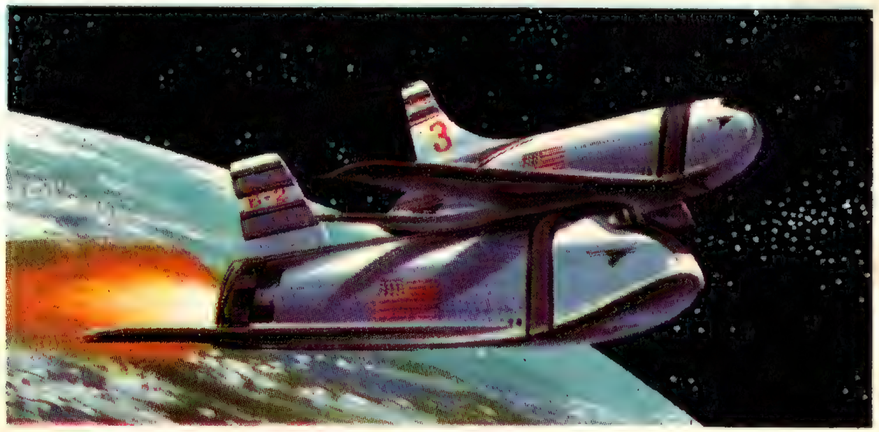


44. Viking. The most advanced American unmanned spacecraft for which firm plans exist is Viking, designed to soft-land instruments on Mars to test whether life exists there. Two 8,000 lb Vikings will be launched on the seven-month journey in 1975. Near Mars each will detach a 1,200 lb capsule which will be commanded to enter the Martian atmosphere. Slowed by atmospheric braking and retro-rockets, they will soft-land and extend aerials and mechanical scoops. Soil samples will be examined for biological traces and the data transmitted to Earth.

44. One of several flight plans under consideration calls for the spacecraft to be placed in orbit around Mars for a photographic survey of the planet, and to decide the most suitable place for landing before the descent to the surface. In another scheme, the capsule will be landed in a predetermined area, from where it would return data to help decide on a landing site for the second spacecraft. In both cases the orbiter modules would then serve as a radio relay between the lander and Earth-based tracking stations.

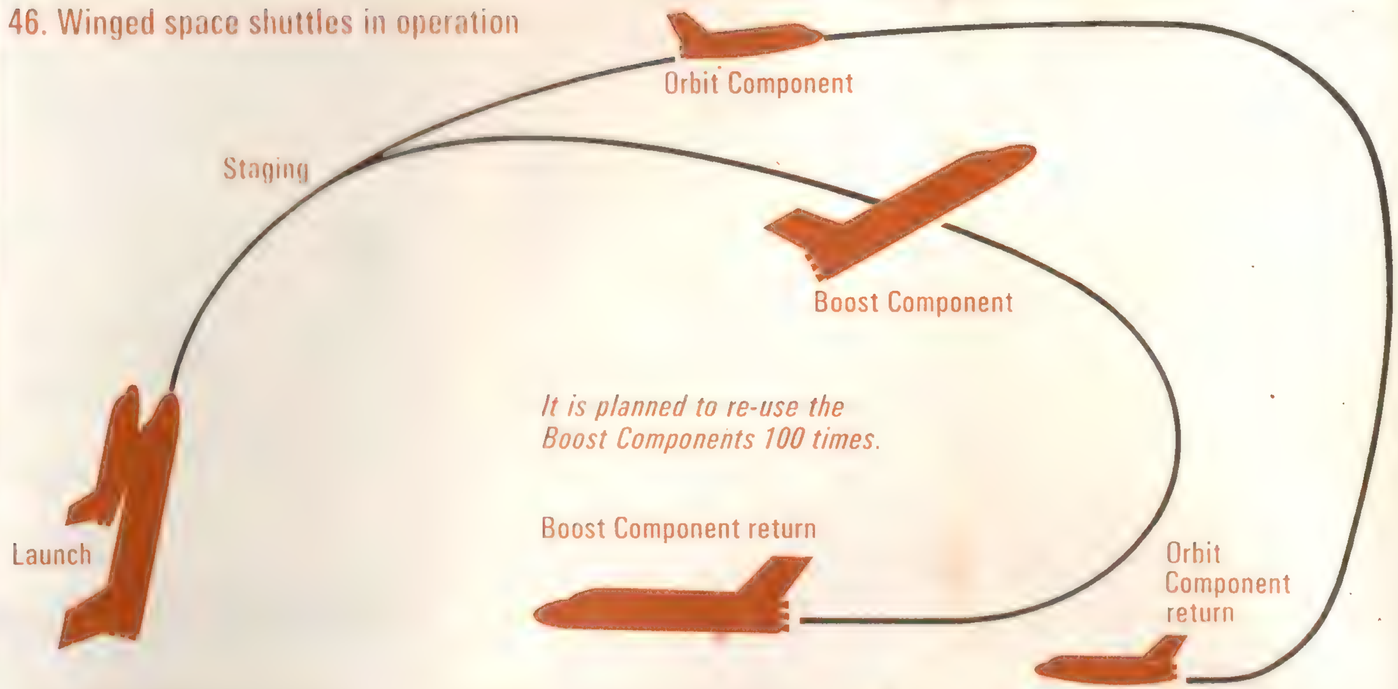
45. In future some of the world's most advanced research will be carried out in orbiting space stations. In prospect are unique experiments in medicine and biology and the development of new materials and industrial products under weightlessness. Detailed observation will be made of Earth's weather patterns, providing advance warning of storms, floods, snow and sea ice, and air and water pollution. Los Angeles smog has already been photographed from space! Earth's natural resources will also be surveyed.

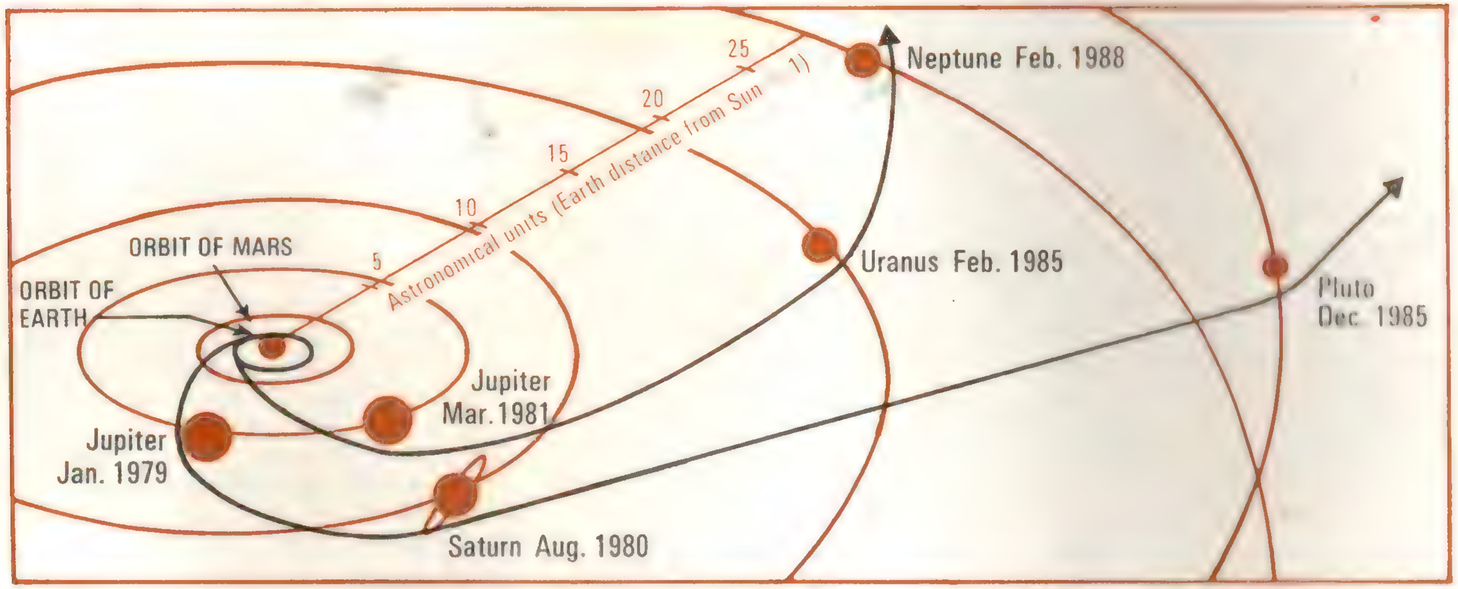
45. 12-man Space Station. After experimenting with 'Skylab', America expects to build a fully-fledged space station in Earth-orbit where men can live and work for long periods. Launched separately and assembled in orbit by astronauts, cylindrical modules contain rooms for sleeping, personal hygiene and recreation as well as laboratories for science and technology, as shown in the cutaway illustration. Tasks include astronomy, observation of land and sea, Earth-resources survey, meteorology and advance warning of storms, floods and air and water pollution; also envisaged are unique factory processes benefiting from weightlessness and vacuum. Re-usable space shuttles keep the station supplied with air, food and other expendables.



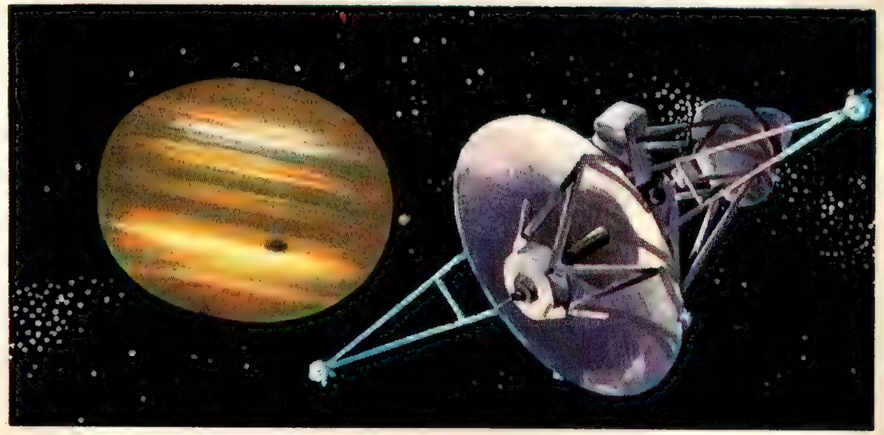
46. Space Shuttle. Two-stage piloted space planes which take-off vertically like rockets but land on a runway like jet-transports are planned in America to replace the present throwaway space rockets. The illustration shows a winged orbiter about to separate from a winged booster 200,000 feet above the Earth. While the orbiter continues into orbit—where it may remain for up to two weeks—the booster flies back to base. The orbiter carries 25,000 to 50,000 lb payloads, a large communications satellite or interplanetary space probe, or space station supplies—in its cargo hold.

46. Winged space shuttles in operation

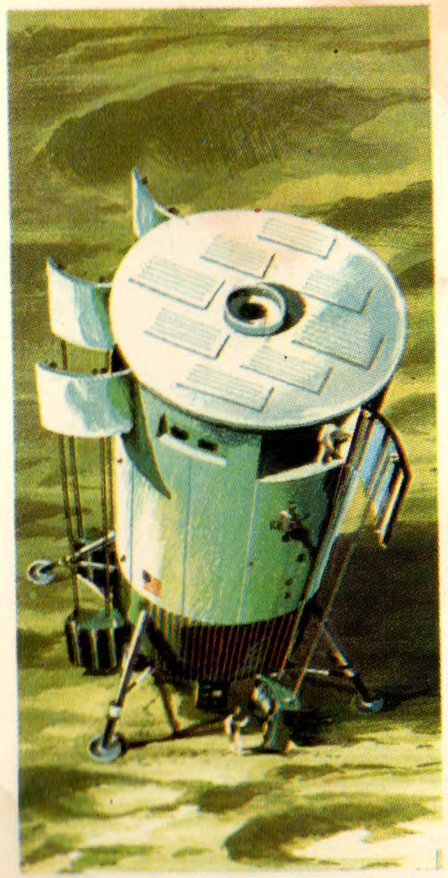




47. The exact layout of the spacecraft is not yet finalised, the card illustration showing one possible configuration. In multi-planet reconnaissance, the less time taken, the greater the chance of success, for it is easier to make a spacecraft operate reliably for nine years than 18 years. A similar conjunction of the outer planets will not recur for over 170 years. Two possible missions are shown, with the trajectories and the planets' fly-by dates.

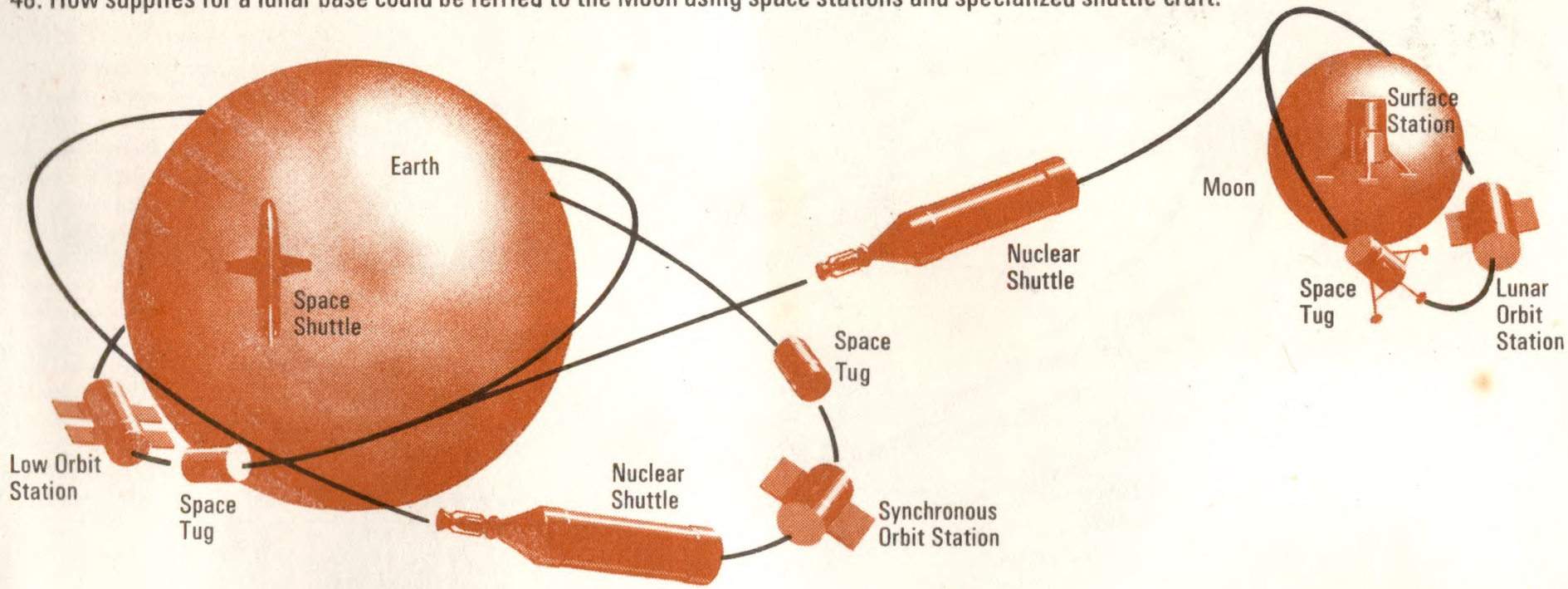


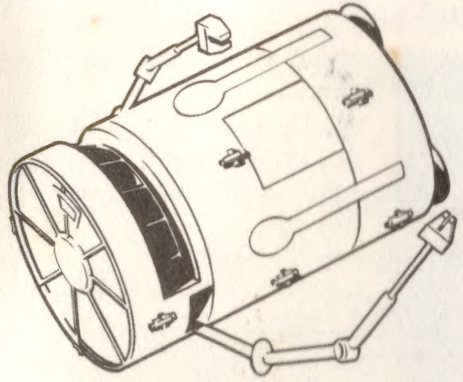
47. The Grand Tour is a proposal by NASA for a reconnaissance mission in 1977-1978 to the outer planets of the solar system—Jupiter, Saturn, Uranus, Neptune and Pluto. It is the most ambitious unmanned space project known at the present time. In 1977 the relative positions of the five planets will be such that a 2,000 lb. spacecraft, launched by a relatively small rocket, may be accelerated by gravity, as it passes each planet in turn, to such a speed that the journey to Neptune, which normally would take eighteen years, could be achieved in only nine years.



48. Lunar Shuttle. Once manned space-stations have been established in Earth-orbit, it will be possible to assemble spaceships from separate modules carried aloft by re-usable space shuttles or expendable rockets. In prospect is a nuclear-powered Nerva rocket which shuttles back and forth between Earth-orbit and lunar-orbit, being continuously refuelled with liquid hydrogen brought to the space station by winged shuttles. It ferries pre-fabricated parts for a Moon-base into lunar orbit for transfer to a chemically-powered landing craft (illustrated), similar to the Apollo lunar module. The type of nuclear engine used in the lunar shuttle could also power ships of the manned Mars Expedition.

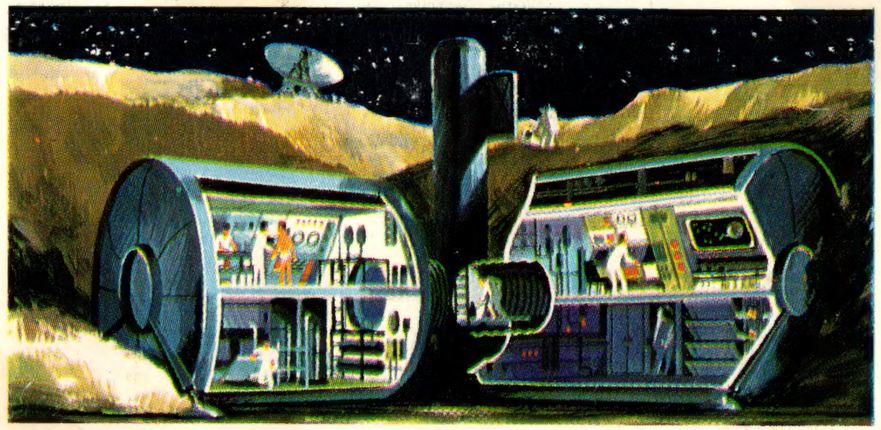
48. How supplies for a lunar base could be ferried to the Moon using space stations and specialized shuttle craft.



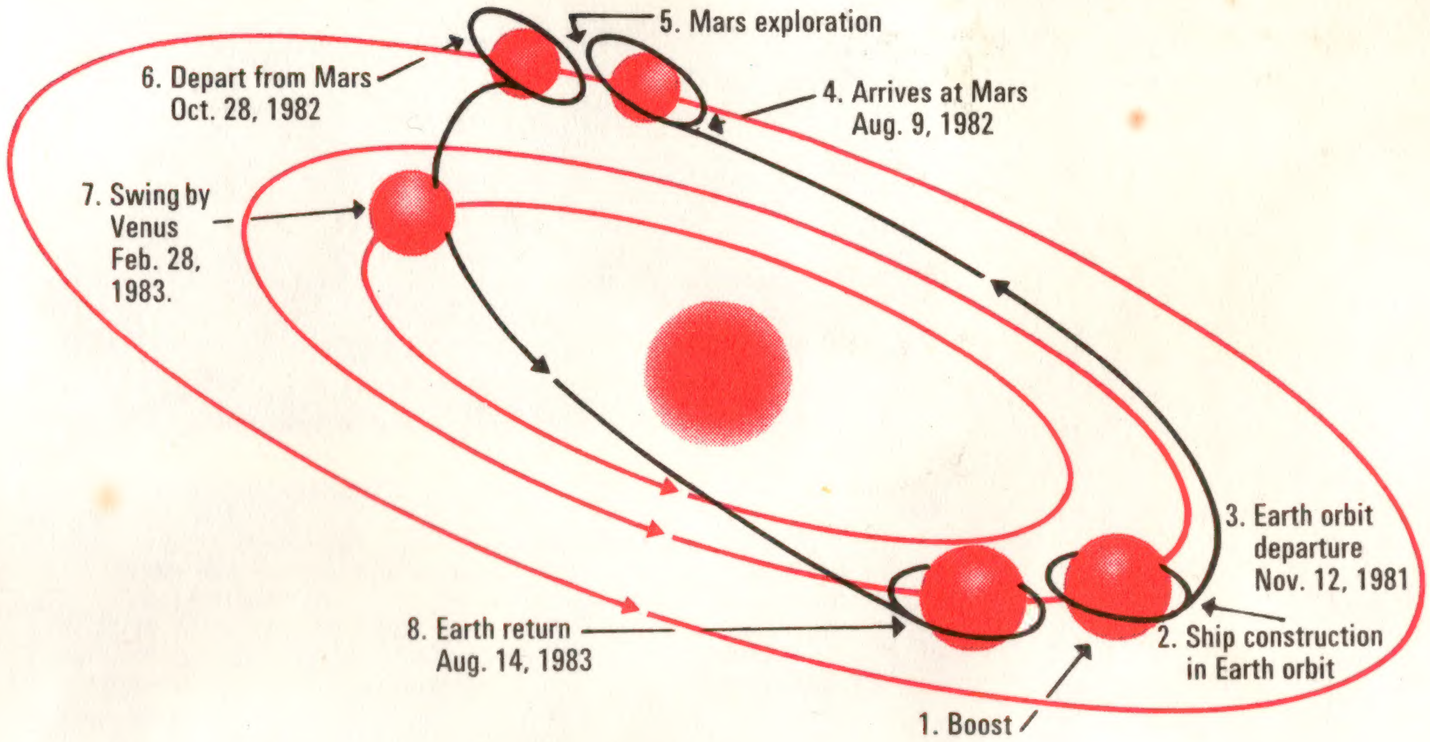


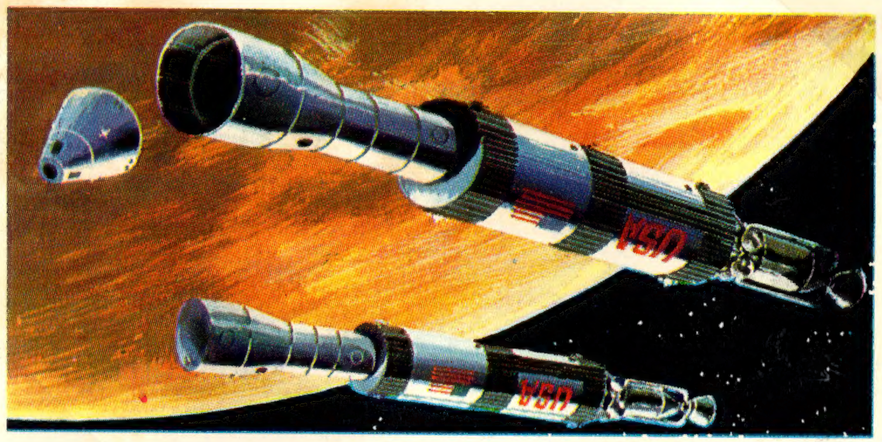
In this operation the space tug will play a vital role. Capable of being manoeuvred into different orbits, it will ferry cargo between the space station and other orbiting vehicles. Fitted with mechanical arms, it can also be used in repair, assembly and rescue operations.

49. If oxygen and hydrogen can be extracted from raw materials on the Moon, a future technology could establish a re-fuelling base for spaceships taking advantage of the Moon's low gravity. The discovery of water beneath the surface would be an enormous boon. A small industrial colony might then develop manufacturing its own air for pressurized buildings, and growing its own food in hydroponic farms. The moon may well become a major astronomical observation centre, due to its lack of atmosphere.



49. Moon Base. Once the transportation problem is solved, prefabricated parts ferried to the Moon can be used to build the equivalent of 'Scott Base' on the lunar surface. As the Moon has no air, pressurized buildings must have airlocks to preserve vital oxygen while astronauts leave and enter. Once inside, cumbersome spacesuits can be removed. Air-conditioning must cater for wide temperature extremes, up to 243°F during the lunar day and down to —279°F at night. Buildings, double-walled for protection against meteoroids, may possibly be buried in natural caves.





50. The Manned Flight to Mars. America's plan for a manned expedition to Mars involves two nuclear-powered spaceships, each carrying six astronauts, launched (according to one plan), on Nov. 12, 1981. Reaching Mars on Aug. 9, 1982, each vehicle would orbit the planet for 80 days while unmanned probes, followed by three men from each ship, would descend to carry out scientific research and collect samples. During the return to Earth (landing on Aug. 14, 1983) the expedition would fly past Venus to observe the planet and use its gravity to reduce speed.

50. The project to land men on Mars took a step forward on Sept. 15, 1969, when President Nixon's adviser presented him with proposals for such a voyage. For all its exciting and visionary aspect, the plan is technically feasible. What is less certain is whether the world's richest nation will be willing to invest a significant proportion of its capital in such an enterprise. Many scientists feel that such a project would absorb all the money—costing perhaps £80,000,000,000—which would have otherwise supported a more widely based unmanned programme of exploration of the solar system.

A glossary of some not-so-familiar terms used in this Album

Aneroid pressure sensors – ejection mechanism operated by atmosphere sensing switch.
Attitude-stabilisation – maintenance of the attitude of a satellite or spacecraft by rotation about an axis (also known as ***spin-stabilisation***) or by use of small rocket engines on non-rotating craft
Ballistic missile – military rocket having no propulsion over the majority of its trajectory.
Bioshield – protective shield sealing surgically clean spacecraft so as not to carry Earthly germs into another planet's environment.
Canopus star tracker – optical device which seeks and continuously points to the star *Canopus*, providing one of the three references needed for a spacecraft to maintain a given position.
Coarse sun sensor – active device which enables the spacecraft to be aligned approximately with the sun for attitude control purposes.
Comsat – communications satellite.
Hydroponics – technique for growing plants in water with added chemical nutrients.
Inertial reference unit – a device which measures very small accelerations acting on the spacecraft, and converts them to velocities.
Lysogenic bacteria – simple organism used for biological research.
Mylar – a very thin plastic material.
Orbit – a closed path around a heavenly body in which a satellite moves.
Passive satellite – a satellite that operates merely by virtue of its presence (e.g. as a radar reflector or for optical sighting) in space; ***an active satellite*** amplifies or otherwise processes an incoming signal before retransmission.
S-band communication system – operates frequencies of about 2.6 to 3.95 thousand million cycles per second.
Trajectory – segment of the path travelled by a craft in space.
Transponder – radio equipment which retransmits a received signal at a different frequency.
Vernier – small rocket whose function is to maintain a given attitude in space or to provide a small change in velocity.
Yaw manoeuvre – rotation of a spacecraft to face a new direction.

NASA – National Aeronautics and Space Administration.

Cape Canaveral/Cape Kennedy On Nov. 29, 1963 NASA's Launch Operations Centre was renamed The John F. Kennedy Space Centre and Cape Canaveral renamed Cape Kennedy. A tribute to the champion of Space research who was assassinated on Nov. 22, 1963.

ACKNOWLEDGEMENTS. Brooke Bond Oxo Ltd gratefully acknowledge the co-operation of the National Aeronautics and Space Administration, the United States Information Service, the Novosti Press Agency, and the Embassy of Japan in the preparation of illustrations. Also these companies have supplied details of original studies: Boeing and General Motors (Lunar Roving Vehicle); North American Rockwell (12-Man Space Station), and Grumman Aerospace (Space Shuttle and Lunar Shuttle).

Gherman Titov

Andriyan Nikolaev

Pavel Popovich

Valery Bykovsky

Konstantin Feoktistov

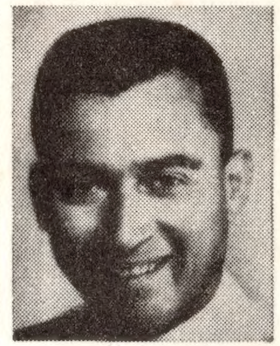
Boris Yegorov

Pennant of the U.S.S.R. affixed to Luna 12 moon satellite, launched Oct. 22, 1966

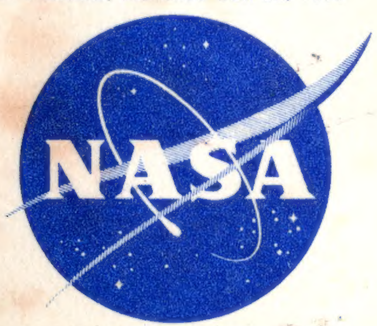
M. Scott Carpenter

Walter Schirra

Leroy Cooper



John Young



NASA symbol

Edwin Aldrin

Michael Collins

Neil Armstrong

Alan Bean

Frank Borman

William Anders

James Lovell

Fred Haise

John Swigert

Charles Conrad

Some interesting books to read

Space by Patrick Moore. Lutterworth Press, 65/–
The Promise of Space by Arthur C. Clarke. Hodder & Stoughton, 70/–
Wonders of Space by R. Wyler and E. Aimes. Paul Hamlyn, 12/6d
Manned Spacecraft by Kenneth W. Gatland. Blandford Press, 18/–
Frontiers of Space by Philip Bono and Kenneth W. Gatland. Blandford Press, 21/–
Telescopes in Space by Z. Kopal. Faber, 50/–
Project Apollo by T. Alexander. Muller, 25/–
Soviet Space Exploration – The First Decade by William Shelton. Barker, 45/–
Observing Earth Satellites by Desmond King-Hele. Macmillan, 30/–
Flight to the Stars by James Strong. Temple Press, 25/–
Project Apollo: The Way to the Moon by Booker, Frewer and Pardoe. Chatto and Windus, 36/–
An Introduction to Space. HMSO, 21/–
The Encyclopedia of Space Edited by Maurice Allward. Paul Hamlyn, 7 gns.
Journey to Tranquillity by Young, Silcock and Dunn. Jonathan Cape, 42/–
The Invasion of the Moon by Peter Ryan. Penguin Books, 5/–
Flight International IPC Business Press. Weekly, 2/6 (Only two English-speaking weekly periodicals carry regular columns devoted to all aspects of space flight; these are the American magazine *Aviation Week*, and the British *Flight International*)
Spaceflight published by the British Interplanetary Society appears monthly and is available free of charge to Members or on subscription.

Scientific Societies

British Astronomical Association
Anyone interested in astronomy could do no better than to join this association. Its publications include a bi-monthly *Journal* and a yearly *Handbook*. There are monthly meetings in London from October to June, observing groups, library facilities, lantern slides and film strips. Members may also obtain instruments on loan. Membership particulars are obtainable from the Assistant Secretary, British Astronomical Association, Burlington House, Piccadilly, London, W1V 0NL.

British Interplanetary Society
This Society, established in 1933, has wide international interests in rocketry and space exploration. It publishes the magazine *Spaceflight* and a technical *Journal*, both monthly. Library facilities are available to members by post. Lectures and film shows and technical meetings are held in London and many provincial centres. Membership particulars are obtainable from the Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London SW1. Tel: 01-828-9371.

The London Planetarium

A complex optical projector here enables the universe – past, present and future – to be examined in detail as stars and planets are projected on the spherical ceiling.

THE BERKSHIRE PRINTING CO. LTD., READING, ENGLAND

This series of Picture Cards is offered in the interests of education by

BROOKE BOND OXO LTD

Picture Cards are given free with Brooke Bond Tea and Tea Bags